Mining and Metallurgy

American Institute of Mining, Metallurgical,
and Petroleum Engineers


1837
ARTES
VERITAS
SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
E PLURIBUS UNUM
TUEBOR
SI QUAERIS PENINSULAM AMOENAM
CIRCUMSPICE

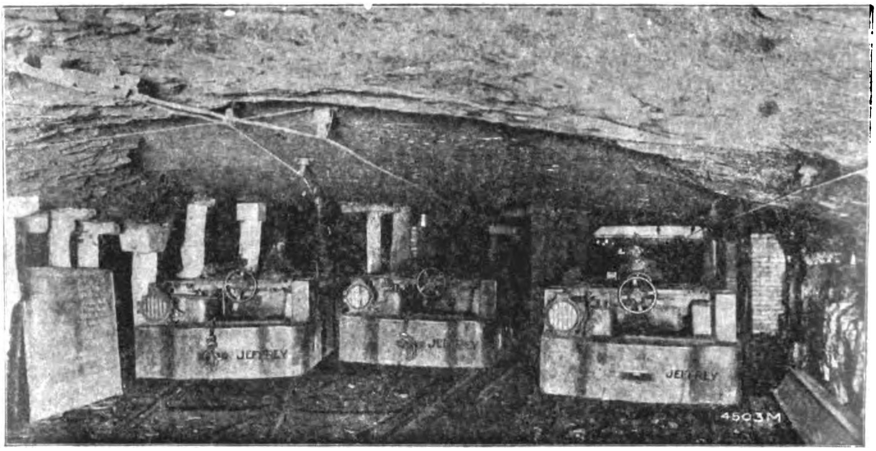
No. 61 JANUARY 191

Bulletin of the American Institute of Mining Engineers.

CONTENTS:

SECTION I.—INSTITUTE ANNOUNCEMENTS. PA

SECTION II. PAPERS AND DISCUSSIONS.


4503M

BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

No. 61 JANUARY 1912

PUBLISHED MONTHLY
BY THE AMERICAN INSTITUTE OF MINING ENGINEERS
at 124 to 128 N. Seventh St., Philadelphia, Pa.
Guy R. Overend, Publication Manager.

Editorial Office, 29 West 39th St., New York, N. Y.

JOSEPH STRUTHERS, Ph.D., Editor.

Cable address, "Aime," Western Union Telegraph Code.

Subscription (including postage), $10 per annum; to members of the Institute, public libraries, educational institutions and technical societies, $5 per annum.

Single copies (including postage), $1 each; to members of the Institute, public libraries, etc., 50 cents each.

Entered as second class matter, October 16, 1911, at the post office at Philadelphia, Pa., under the Act of March 3, 1879.

TABLE OF CONTENTS.

SECTION I. INSTITUTE ANNOUNCEMENTS.

SECTION II. TECHNICAL PAPERS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

The papers contained in Section II. have been so printed and arranged (blank pages being left when necessary) that they can be separately removed for classified filing, or other independent use. A small stock of separate pamphlets is reserved for those who desire extra copies of any single paper.

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

All communications concerning the contents of this Bulletin should be addressed to JOSEPH STRUTHERS, Ph.D., Secretary and Editor, 29 W. 39th St., New York, N. Y.

OFFICERS.

For the year ending February, 1912.

COUNCIL.*

PRESIDENT OF THE COUNCIL.

CHARLES KIRCHHOFF........New York, N. Y.

(Term expires February, 1912.)

VICE-PRESIDENTS OF THE COUNCIL.

BENJAMIN B. LAWRENCE........New York, N. Y.
JOSEPH W. RICHARDS........South Bethlehem, Pa.
ALBERT SAUVEUR........Cambridge, Mass.

(Term expires February, 1912.)

S. B. CHRISTY........Berkeley, Cal.
W. A. LATHROP........Philadelphia, Pa.
GARDNER F. WILLIAMS........Washington, D. C.

(Term expires February, 1913.)

COUNCILORS.

KARL EILERS........New York, N. Y.
ALEX. C. HUMPHREYS........New York, N. Y.
W. G. MILLER........Toronto, Canada.

(Term expires February, 1912.)

ROBERT E. JENNINGS........New York, N. Y.
WILLIAM KELLY........Vulcan, Mich.
CHARLES F. RAND........New York, N. Y.

(Term expires February, 1913.)

A. E. CARLTON........Cripple Creek, Colo.
W. J. OLCOTT........Duluth, Minn.
E. L. YOUNG........New York, N. Y.

(Term expires February, 1914.)

SECRETARY OF THE COUNCIL AND EDITOR.

JOSEPH STRUTHERS, 29 W. 39th St........New York, N. Y.

(Term expires February, 1912.)

SECRETARY EMERITUS OF THE COUNCIL.

R. W. RAYMOND........New York, N. Y.

CORPORATION.

JAMES GAYLEY, President; JAMES DOUGLAS, Vice-President;
FRANK LYMAN, Treasurer;
JOSEPH STRUTHERS, Secretary and Assistant Treasurer.

DIRECTORS.

THEODORE DWIGHT, ARTHUR L. WALKER, JOSEPH STRUTHERS.

(Term expires February, 1912.)

JAMES GAYLEY, CHARLES KIRCHHOFF, FRANK LYMAN.

(Term expires February, 1913.)

JAMES DOUGLAS, JAMES F. KEMP, ALBERT R. LEDOUX.

(Term expires February, 1914.)

---

* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation, and is therefore, for convenience, composed of members residing in New York.

COMMITTEES.

For the year ending February, 1912.

COUNCIL.

Membership:—Joseph Struthers, Benjamin B. Lawrence, Karl Eilers, Charles F. Rand, Edward L. Young.

Publications:—David W. Brunton, Denver, Colo.; Samuel B. Christy, Berkeley, Cal.; Albert L. Colby, South Bethlehem, Pa.; Nathaniel H. Emmons, Copperhill, Tenn.; Charles H. Fulton, Rapid City, S. D.; James Gayley, New York, N. Y.; H. O. Hofman, Jamaica Plain, Mass.; Henry M. Howe, Bedford Hills, N. Y.; Walter R. Ingalls, New York, N. Y.; James F. Kemp, New York, N. Y.; R. V. Norris, Wilkes-Barre, Pa.; Edward D. Peters, Dorchester, Mass.; Rossiter W. Raymond, New York, N. Y.; Joseph W. Richards, South Bethlehem, Pa.; Robert H. Richards, Boston, Mass.; Albert Sauveur, Cambridge, Mass.; Henry L. Smyth, Watertown, Mass.; Arthur L. Walker, New York, N. Y.

CORPORATION.

Finance:—James Douglas, Albert R. Ledoux, Theodore Dwight.
Library:—Joseph Struthers, James F. Kemp, Arthur L. Walker.

INSTITUTE REPRESENTATIVES.

United Engineering Society Trustees:—Eben E. Olcott (1912), Joseph Struthers (1913), Theodore Dwight (1914).

John Fritz Medal Board of Award:—Eben E. Olcott (1912), E. Gybbon Spilsbury (1913), James Douglas (1914), Charles Kirchhoff (1915).

American Association for the Advancement of Science:—H. O. Hofman, Boston, Mass.; John D. Irving, New Haven, Conn.

Eighth International Congress of Applied Chemistry, New York, September, 1912:—William L. Saunders, New York, N. Y.; George C. Stone, New York, N. Y.

International Association for Testing Materials Congress, Chicago, September, 1912:—Robert Forsyth, Chicago, Ill.

Committee No. 24, International Association for Testing Materials:—Henry D. Hibbard, Plainfield, N. J.

International Engineering Congress, San Francisco, 1915:—Samuel B. Christy, William C. Ralston, Edwin T. Blake.

Nomination of Officers and Council, 1912:—E. Gybbon Spilsbury, Chairman; J. R. Finlay, L. D. Huntoon, Arthur S. Dwight, Charles P. Perin.

CONSULTING ATTORNEYS.

Blair & Rudd, New York, N. Y.

INSTITUTE ANNOUNCEMENTS.

Back Volumes of the Transactions.

The Board of Directors has authorized the following offers of sets of back volumes of the *Transactions*, at considerably reduced prices, to Members, Libraries, and Scientific Societies:

	Per Set.
I. Five volumes, bound in half-morocco, from No. 36 (1906) to No. 40 (1910), ...	$20
II. Ten volumes, bound in half-morocco, from No. 31 (1902) to No. 40 (1910), including Mexican Volume, . .	35
III. Twenty volumes, bound in half-morocco, from No. 21 (1893) to No. 40 (1910), ...	50
IV. Thirty volumes, bound in half-morocco, from No. 11 (1883) to No. 40 (1910), ...	60
V. Thirty-nine volumes, bound in half-morocco, from No. 1 (1873) to No. 40 (1910), with the exception of No. 10 (1882), but including index for Volumes Nos. 1 to 35, and Nos. 36 to 40, ...	75
VI. Nine volumes, bound in half-morocco, from No. 1 (1873) to No. 9 (1881), ...	25

Applications should be addressed to Joseph Struthers, Secretary, 29 West 39th Street, New York, N. Y.

Deferred Publication of the Year Book.

The *Year Book* of the Institute, which heretofore has been sent out with the January number of the *Bulletin*, and has covered the calendar year, Jan. 1 to Dec. 31, will not be issued this year until after the date of the Annual Meeting of the Institute, Feb. 20, 1912, thereby conforming to the official year of the Institute.

Changes of address received before Feb. 1, 1912, will be included in this edition of the *Year Book*.

Special Notice.

The *Bulletin* is now entered at the Post Office at Second-Class Postage rate of one cent per pound, and in order to preserve this privilege it will be necessary that the dues of members be paid within four months of Jan. 1, 1912. If the dues are not paid within the period mentioned, a member's name must be removed from the regular subscription-list and the *Bulletin* mailed at the transient second-class postage rate of one cent for each four ounces or fraction thereof, prepaid by stamps affixed. It is therefore earnestly requested that dues be paid promptly—otherwise the Institute will be put to additional expense of postage and to added labor in removing and replacing names from the regular list, and maintaining an additional separate mailing-list.

Library Research-Work.

The attention of members of the Institute is again directed to the research-work done by the librarian and his assistants, which should attract special attention from those members who have no access to the literature of subjects in which they may be interested. A list of recent searches follows:

Combustion of coal-dust; fusibility of ash; pyritic smelting; burning small sizes of coal; chromite-ore in Cuba; shaft-sinking; oil-pipe lines; cost of producing open-hearth steel; smoke-abatement; tunneling-machines; alloys of aluminum; mining asbestos; bog ore; boron manufacture; filter-presses (cyanide process); iron-ores from Yorkshire; mineral resources of Cyprus; electrolytic refining of copper; copper-deposits of Maryland; iron- and copper-deposits in Cuba; liquid and gaseous fuels; graphite in Ceylon; gold-dredges and dredging; graphite manufacture; Lowe gas-producer; occurrence of magnesite; molybdenum; acid mine-water; gold-fields in Nevada; sulphur in Santo Domingo; timbering and lining of circular shafts; mines in Venezuela.

Local Sections.

The following regulations for the establishment of Local Sections of the Institute, issued in circular form and distributed to the membership May 26, 1911, are here republished for more convenient reference.

Regulations for the Formation and Conduct of Local Sections.
(Adopted May 19, 1911.)

1. A Local Section of the Institute may be authorized by the Council at the written request of *ten* members residing within an appropriate distance of a central point.
2. Only one Section shall be authorized in one locality or district.
3. The Council shall define the territory of a Section.
4. A Section must consist of twenty-five or more members; when its membership falls below twenty-five in number the Council may annul the Section.
5. Only members of the Institute shall be members of its Local Sections.
6. All members of the Institute, of all grades, residing within the territory of a Section shall *ipso facto* constitute the membership of such Section.
7. The officers of a Section shall be elected after the formation of the Section has been duly authorized, at a meeting of the members of the Institute within the territory of said Section, called by the sponsors of the Section, notice of said meeting and its object being given to said members at least thirty days in advance. Officers shall be elected for a term not longer than one year.
8. The officers of a Local Section shall be a Chairman, Vice-Chairman, Secretary, Treasurer (or Secretary-Treasurer), and such others as the Section may desire.

9. Whenever the Institute is financially able to do so, it shall be the policy of its Board of Directors to contribute from its funds for the legitimate running expenses of each Local Section an amount not exceeding, in each year, 25 per cent. of the dues received from the members of said Section in said year. Requests for such appropriations shall be signed by the Chairman, Secretary and Treasurer of the Section.

10. If the expenses of a Section exceed the appropriation made it by the Institute, the difference must be made up by voluntary contributions, but not by assessment upon the members of said Section. The Institute shall not be responsible for the debts of its Sections.

11. The Institute reserves the right to cancel a Section, or re-adjust its territory.

12. Papers presented at Local Sections, and discussions thereon if reported, are the property of the Institute. They shall be submitted to the Publication Committee and published in the *Bulletin* or *Transactions*, or both, if approved. Such papers shall not be published elsewhere without permission of the Council. The reading of a paper before a Local Section shall not carry with it the right of publication in the *Bulletin* or *Transactions* of the Institute.

13. Neither the author of a paper presented to a Local Section nor the Local Section shall have the right to reprint a paper or publish it in advance of the meeting without obtaining the permission of the Publication Committee of the Institute, which shall determine the details of such permission. Nothing herein shall forbid the abstracting of a paper by the press *after* its presentation before the Local Section.

14. The Institute shall print advance copies of papers offered to Local Sections, in order to facilitate discussion thereon, provided that such papers are approved for such advance publication by the Chairman or Secretary of the Local Section and by the Publication Committee of the Institute.

15. Papers read before a Local Section may also be offered for reading or discussion at general meetings of the Institute, and shall be given equal standing with the other papers on the program of said meeting, when approved by the Publication Committee.

16. Each Local Section shall transmit promptly to the Secretary of the Institute full announcements of its proposed meetings and an abstract of its proceedings, including the names of authors and titles of all papers read before it, for the purpose of preparing a report thereon to be published in the *Bulletin* of the Institute, and for the purpose of enabling the Council of the Institute to comply with articles 17 and 19 of these regulations.

17. The By-Laws and regulations of Local Sections shall be subject to the approval of the Council.

18. The Council reserves the right to amend, annul, or add to these regulations.

19. No action shall be taken by a Section which shall contravene the Constitution of this Institute.

CHARLES KIRCHHOFF, *President;*
JOSEPH STRUTHERS, *Secretary.*

The Emmons Research Fellowship of Economic Geology.

The Committee named below has been formed by friends of Samuel Franklin Emmons, late of the United States Geological Survey, to consider the best method of perpetuating his name. It has been decided that the memorial to him shall take the shape of a Research Fellowship, to be known as the Samuel Franklin Emmons Research Fellowship of Economic Geology, which is to be administered by Prof. James F. Kemp, of Columbia University, New York. Subscriptions are invited by his friends to this fund, which the Committee has fixed at $25,000.

Members of the Institute who desire to contribute to this fund will please communicate with the Treasurer, Benjamin B. Lawrence, 60 Wall Street, New York.

The Committee consists of the following:

GEORGE OTIS SMITH, Director, U. S. Geological Survey, Washington, D. C.

H. L. SMYTH, Harvard University, Cambridge, Mass.

JAMES DOUGLAS, 99 John Street, New York, N. Y.

J. A. HOLMES, Director, Bureau of Mines, Washington, D. C.

JAMES F. KEMP, Columbia University, New York, N. Y.

F. W. BRADLEY, San Francisco, Cal.

J. PARKE CHANNING, 42 Broadway, New York, N. Y.

SEELEY W. MUDD, 1001 Central Building, Los Angeles, Cal.

D. W. BRUNTON, Denver, Colo.

H. FOSTER BAIN, 420 Market Street, San Francisco, Cal.

T. A. RICKARD, London, England.

B. B. LAWRENCE, 60 Wall Street, New York, N. Y.

Regulations for the Committee on Publication.

(*Accepted by the Council, June* 16, 1911.)

1. The formation of a Publication Committee, consisting of the Secretary-Editor of the Institute, *Chairman*, and of at least twelve specialists, members of the Institute, who are willing to assist in passing on all papers offered for publication.

2. This committee shall perform its functions as follows:

(*a*) On the receipt of a paper by the Secretary, he shall send it to the member of this committee who, in his judgment, is most competent to pass upon it, accompanying the paper with his own opinion of its suitableness for publication, the history of the paper, and any other pertinent information.

(*b*) If the member of the committee and the Chairman agree upon the suitability or unsuitability of the paper, it shall be considered accepted for publication or rejected, as the case may be.

(*c*) If these two do not agree, the paper shall be submitted to a third, and the opinion of two of these three shall decide the matter.

(*d*) If a paper has been refused publication, the author may have the right of appeal, in which case the persons previously passing on the paper, together with others of the committee (appointed by the President) making five altogether, shall decide the question.

(*e*) If a paper has been accepted for publication, it shall be considered eligible to be placed on the program of a meeting.

3. The placing of a paper upon the program of a meeting does not give it the right to be published in the *Bulletin* or *Transactions* of the Institute; its suitability for publication must in every case be passed upon by the Publication Committee, as provided for in Section 2.

4. In case the Secretary is unable to secure a decision as to the suitability or unsuitability of a paper for publication, as directed in Section 2, before the time of announcing the program of a meeting, he may at his own discretion place the paper upon the program of the meeting, or refuse it a place thereon.

PUBLICATION COMMITTEE.

(*Appointed by the Council, Sept.* 20, 1911.)

The Secretary-Editor of the Institute, *Chairman*; David W. Brunton, Samuel B. Christy, Albert L. Colby, Nathaniel H. Emmons, Charles H. Fulton, James Gayley, H. O. Hofman, Henry M. Howe, Walter R. Ingalls, James F. Kemp, R. V. Norris, Edward D. Peters, Rossiter W. Raymond, Joseph W. Richards, Robert H. Richards, Albert Sauveur, Henry L. Smyth, and Arthur L. Walker.

Affiliated Student Societies.

Any society of undergraduates at a technical school, comprising students in any branch of engineering, metallurgy, chemistry, geology, etc., may be recognized by the Council in its discretion as an Affiliated Student Society. A circular giving details of the plan of affiliation may be obtained on application to the office of the Secretary of the Institute.

The following societies have been placed by authority of the Council on the above list:

AFFILIATED STUDENT SOCIETIES.

The Mining Society of the Sheffield Scientific School, Hammond Laboratory, New Haven, Conn. *President*, Karl C. Stadtmiller; *Secretary*, S. B. Gordy.

The University of Illinois Student Branch of the American Institute of Mining Engineers, Champaign, Ill. *President*, A. L. Voight; *Secretary*, M. L. Nebel.

The Engineering Society of the University of Nevada, Reno, Nev. *President*, Walter Harris; *Secretary*, E. R. Bennett.

The University of Wisconsin Mining Club, Madison, Wis. *President*, H. E. Schmidt; *Secretary*, W. V. Bickelhaupt.

The Mining and Geological Society of Lehigh University, South Bethlehem, Pa. *President*, William E. Fairhurst; *Secretary*, Carl W. Mitman.

The School of Mines Society of the University of Minnesota, Minneapolis, Minn. *President*, Emory P. Baker.

The Mining Engineering Society of the Massachusetts Institute of Technology. *President*, L. B. Duke; *Secretary*, Lionel H. Lehmaier.

The Student Auxiliary Society of the American Institute of Mining Engineers of the University of Kansas, Lawrence, Kan. *President*, A. H. Mangelsdorf; *Secretary*, C. J. Hainbach.

The Associated Miners of the University of Idaho, Moscow, Idaho. *President*, James W. Gwinn; *Secretary*, J. Wallace Strohecker.

The State College of Washington Mining and Geological Society, Pullman, Wash. *President*, R. V. Ageton; *Secretary*, W. M. McCarty.

The Tejas Technical Society, School of Mines, University of Texas. *President*, G. C. Cartwright; *Secretary*, David S. Alley.

The Ohio State University Student Branch of the American Institute of Mining Engineers, Columbus, Ohio. *President*, Hugh B. Lee; *Secretary*, E. P. Elliott.

The Stanford Geology and Mining Society, Stanford University, Cal. *President*, B. E. Parsons; *Secretary*, E. D. Nolan.

The Senior Mining Society of Columbia University, New York, N. Y. *President*, Roger L. Strobel; *Secretary*, Clark G. Mitchell.

Mining Association of the University of California, Berkeley, Cal. *President*, W. E. De Berry; *Secretary*, J. F. Dodge.

Tufts College Chemical Society, Tufts College, Mass. *President*, P. G. Savage; *Secretary*, W. S. Frost.

University of Washington Mining Society, Seattle, Wash. *President*, W. R. Canton; *Secretary*, Harold Cogswell.

Student Branch of the American Institute of Mining Engineers, Iowa State College, Ames, Iowa. *President*, M. B. Hadley; *Secretary*, R. L. Hurst.

Missouri Mining Association of the Missouri School of Mines, Rolla, Mo. *President*, D. L. Forrester; *Secretary*, J. S. Irwin.

The Pick and Shovel Club of the Case School of Applied Science, Cleveland, Ohio. *President*, L. B. Riddle; *Secretary*, S. C. Stillwagon.

Colorado School of Mines Scientific Society, Golden, Colo. *President*, Alan Kissock; *Secretary*, George Wilfley.

How to Use the "Transactions" of the Institute.

Buy a copy of the Complete Analytical and Alphabetical Index of Volumes I. to XXXV., inclusive; also the new Index of Volumes XXXVI. to XL.

Whether you do or do not own a full set of the *Transactions*, these Indexes will make all of the material contained in the forty volumes available at once without detailed research into each volume separately. Moreover, an easy search will show what particular papers you need to know more about, and perhaps to study. Thus, any person possessing these Indexes can ascertain at once what has been published in the *Transactions* on a given question, and can learn, by writing to the Secretary, what is its nature, whether it is still to be had in pamphlet form, where it can be consulted in a public library, at what cost it can be copied by hand, etc., etc.

In short, to those who own complete sets of the *Transactions*, these Indexes will be a great convenience; but to those who do not, they will be a professional necessity.

The Index Volumes I. to XXXV. is an octavo of 706 pages, containing more than 60,000 entries, duly classified with sub-headings, and including abundant cross-references. The limited edition is becoming exhausted. The new Index, Volumes XXXVI. to XL., supplementing the Index Volumes I. to XXXV., brings the classified references up to the date of Volume XL., June, 1910. Prices: Index Volumes I. to XXXV., bound in cloth, $5; bound in half-morocco, to match the *Transactions*, $6. Index Volumes XXXVI. to XL., bound in cloth, $1.50; bound in half-morocco, $2.50. The delivery charges will be paid by the Institute on receipt of the above price.

The New York Section.

On Dec. 20, 1911, Dr. Rossiter W. Raymond, Secretary Emeritus of the Institute, gave an interesting lecture, illustrated with lantern-views, describing the visit of the members and guests of the Institute in Japan. On this occasion the various badges distributed to each member, and a special medal which was struck in honor of the party, were exhibited, as well as an amusing Japanese translation of a toast. There were 105 members present.

On Jan. 5, 1912, the Section was addressed by Dr. Gardner F. Williams, of Washington, D. C., on South African Diamond-Mines. Dr. Williams began with a brief historical review of diamond-mining, from the earliest discovery until the present time, when the annual output has reached a value of £10,000,000. From this point he traced the development of the mines, giving reference meanwhile to the gold-production of South Africa, especially commenting on the fact that the great feature of the development of this enormous industry was the use of the cyanide process.

Dr. Williams showed a large number of beautiful illustrated stereoptican views of diamond-mines, and other interesting views of related character in South Africa. The attendance was 120 or more.

The next meeting of the New York Local Section will be a joint meeting with the American Society of Mechanical Engineers, on Feb. 13, 1912, at which time Robert E. Cranston will give a lecture, The Design and Mechanical Features of the California Gold-Dredge. This paper will be discussed by several members of the American Institute of Mining Engineers.

On March 22, 1912, Prof. James F. Kemp will address the Section on Iron-Mining in Swedish Lapland.

BENJAMIN B. LAWRENCE, *Chairman*,
BRADLEY STOUGHTON, *Secretary*,
165 Broadway, New York, N. Y.

Meeting of the Council of the Institute, December 15, 1911.

The following action of the Council at the meeting, Dec. 15, 1911, is here published for the information of the members of the Institute.

In order to secure effective co-operation on matters of joint interest between the four great engineering societies as a whole, it is proposed that a Joint Conference Committee be formed. The duties of the members of this Committee, two from each of the four societies, shall be to meet for conference on the call of the representatives of any one Society, and to inform the governing boards of their respective societies of matters that have been decided to be of interest to the group of national engineering societies as a whole; also to make such recommendations as the conferees think advisable to guide the action of said Boards.

The President and Secretary of the Council of the Institute were appointed a committee of two to act as the representatives of the Institute in the proposed general conference committee.

At the same meeting Prof. James F. Kemp was appointed a representative of the Institute to serve on the John Fritz Medal Board of Award for the period of four years, beginning January, 1912.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
AMERICAN INSTITUTE OF MINING ENGINEERS.
UNITED ENGINEERING SOCIETY.

WILLIAM P. CUTTER, Librarian.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

The Library contains about 42,000 volumes, including sets of technical periodicals and the publications of scientific and technical societies.

The members of the Institute, with few exceptions, are by the very nature of their profession forced to spend a large portion of their time in localities isolated from sources of information. To such members the Library can render valuable service through correspondence, and letters requesting information will receive special attention. The Library is prepared to furnish references and copies of articles on mining and metallurgical subjects; to determine, if possible, the existence of mining-maps, and to furnish general information as to the geology and mineral resources of all countries as far as these resources are known and published.

It is hoped that the members of the Institute will avail themselves freely of this special service. The Library will welcome inquiries on engineering subjects, and furnish information as far as such information is to be obtained.

All communications should be made as definite as possible so that the information received may be what is desired and not include collateral matter which may not be of interest. In this way the time spent in searching for such collateral matter will be saved, and as a result the information will be sent more promptly and in more usable shape.

The members of the Institute can be of service to the Library by forwarding copies of mining-reports, maps privately issued, and similar material, which will be classified, indexed, and made available to other members.

Suggestions for additions to the Library, either by purchase or personal solicitation as gifts, will be welcomed. It is hoped that members while in the city will use the Library freely, and assurance is given that most careful service will be rendered to them.

Library Accessions.

Dec. 1 to Dec. 31, 1911.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

AMERICAN MINING CONGRESS. Report of Proceedings, 14th Annual Session, 1911. Denver, 1911. (Exchange.)

AUSTRIA. K.K. MINISTERIUM FUR OFFENTLICHE ARBEITEN. Statistik des Bergbaues in Osterreich. 1907–1909 (pts. 1–3); 1910, pt. 1. Wien, 1908–1911. (Exchange.)

BIBLIOGRAPHIE DER DEUTSCHEN ZEITSCHRIFTEN LITERATUR. Vol. XXVII. A. Leipzig, F. Dietrich, 1911. (Purchase.)

BRITISH COLUMBIA COAL AND COKE, Sept., 1911. By W. E. Duncan. Merritt, 1911. (Gift of Author.)

BRITISH FOUNDRYMEN'S ASSOCIATION. Proceedings, 1909–1910. London, n.d. (Exchange.)

BRITISH GUIANA. LANDS AND MINES DEPARTMENT: Report, 1910–1911. Georgetown, 1911. (Gift of British Guiana Lands and Mines Commissioner.)

CHEMISCHE TECHNOLOGIE DER NEUZEIT. Band III., 2–3. By Otto Dammer. Stuttgart, 1911. (Purchase.)

CHICAGO SANITARY DISTRICT. Report on the Sewage Disposal. By George M. Wisner. Chicago, 1911. (Gift of G. M. Wisner.)

COALS AVAILABLE FOR THE MANUFACTURE OF ILLUMINATING GAS. (Bulletin No. 6, Bureau of Mines.) Washington, 1911. (Exchange.)

CONGRESO CIENTIFICO (1° PAN AMERICANO). Ciencias Naturales—Antropológicas y Etnológicas. Tomo I. Santiago de Chile, 1911. (Gift of Congreso Cientifico.)

DESCRIPTIVE CATALOGUE OF THE MARINE REPTILES OF THE OXFORD CLAY. Part I. By C. W. Andrews. London, 1910. (Gift of British Museum.)

DAS ERDÖL. Vol. III. By C. Engler and H. V. Höfer. Leipzig, 1911. (Purchase.)

GEOLOGY AND MINERAL RESOURCES OF A PORTION OF FREMONT COUNTY, WYO. (Bulletin No. 2, Ser. B.) Cheyenne, 1911. (Exchange.)

GEOLOGY OF BUILDING STONES. By J. A. Howe. London, 1910. (Purchase.)

GREAT BRITAIN—MINERAL STATISTICS BRANCH. Mines and Quarries—General Report and Statistics for 1910. Part III.—Output. London, 1911. (Exchange.)

GUIDE TO THE EXHIBITION OF ANIMALS, PLANTS AND MINERALS MENTIONED IN THE BIBLE. (British Museum of Natural History. Special Guide No. 5.) London, 1911. (Gift of British Museum.)

HANDBUCH DER EISEN UND STAHLGIESSEREI. Vol. 1. By C. Geiger. Berlin, 1911. (Purchase.)

HANDBUCH DER MINERALCHEMIE. Band I., Nos. 1–3. By C. Doelter. Dresden, 1911. (Purchase.)

INSTITUTION OF MINING AND METALLURGY. Transactions. Vol. 20. London, 1911. (Exchange.)

L'INTERNATIONALISME SCIENTIFIQUE (SCIENCES PURES ET LETTRES.) By P. H. Eijkman. La Haye, 1911. (Gift of Fondajo por Internacieco.)

IRON AND STEEL INSTITUTE. Carnegie Scholarship Memoirs. Vol. III. London, 1911. (Exchange.)

JAHRBUCH FUR DAS BERG UND HÜTTENWESEN IM KÖNIGREICHE SACHSEN, 1911. Freiberg, 1911. (Exchange.)

JUBILÄUMS KATALOG DER VERLAGSBUCHHANDLUNG WILHELM ENGELMANN, 1811–1911. Leipzig, 1911. (Gift of Wilhelm Engelmann.)

LAY-OUT, DÉSIGN AND CONSTRUCTION OF CHEMICAL AND METALLURGICAL PLANTS. By Oskar Nagel. New York, 1911. (Purchase).

MANUAL FOR ENGINEERS. Tables and other Data for Engineers and Business Men. By Charles E. Ferris. Ed. 16. Knoxville, 1911. (Gift of the Glidden Varnish Co.)

METALLURGIC INDUSTRY IN ITALY. Description of Some of the Principal Works. Milan, Associazione fra gli Industriali Metallurgici Italiani, n. d. (Gift of Iron and Steel Institute.)

DIE METALLURGIE DES WOLFRAMS. By Hans Mennicke. Berlin, 1911. (Purchase.)

MINERAL RESOURCES OF THE PHILIPPINE ISLANDS, 1910. Manila, 1911. (Exchange.)

MINING LAWS OF AUSTRALIA AND NEW ENGLAND. (Bulletin No. 505, U. S. Geological Survey.) Washington, 1911. (Exchange.)

MINING RIGHTS ON THE PUBLIC DOMAIN. Ed. 14. By R. S. Morrison and E. D. DeSoto. Colorado, 1910. (Purchase.)

MINING WITHOUT TIMBER. By R. B. Brinsmade. New York, McGraw Hill Book Co., 1911. (Purchase.)

NATIONAL IRON AND STEEL, COAL AND COKE BLUE BOOK. Ed. 4. Pittsburg, R. L. Polk & Co., 1911. Price, $10. (Gift of Publishers.)

This directory gives lists of manufacturers' of iron and steel, and of coal- and coke-producers, with an index of iron and steel products, a list of directors and officers, and a geographical index. An indispensable reference-book for iron manufactures and for the coal-operator. The information is extremely complete.—W. P. C.

NOUVELLES TABLES TRIGONOMETRIQUES FONDAMENTALES. By H. Andoyer. Paris, 1911. (Purchase.)

OKLAHOMA GEOLOGICAL SURVEY. Preliminary Report on the Road Materials and Road Conditions of Oklahoma. (Bulletin No. 8.) Norman, 1911. (Exchange.)

RAPPORT DES OPÉRATIONS MINIÈRES DANS LA PRÒVINCE DE QUEBEC, 1910. Quebec, 1911. (Gift of Ministère de la Colonisation, des Mines et des Pecheries, Quebec.)

RETRACEMENT OF THE BOUNDARY LINE BETWEEN IDAHO AND WASHINGTON FROM THE JUNCTION OF SNAKE AND CLEARWATER RIVERS NORTHWARD TO THE INTERNATIONAL BOUNDARY. (Bulletin No. 466, U. S. Geological Survey.) Washington, 1911. (Exchange.)

RESULTS OF SPIRIT LEVELING IN ILLINOIS, 1909 and 1910. Bulletin No. 493, U. S. Geological Survey.) Washington, 1911. (Exchange.)

ROYAL INSTITUTE OF BRITISH ARCHITECTS. Kalendar, 1911–1912. London, 1911. (Exchange.)

RUSSIA. COMITÉ GÉOLOGIQUE. Carte Géologique detaillée du Bassin Houiller du Donetz. Description de la feuille VII., 25, 26. St. Petersburg, 1910. (Exchange.)

—— —— Maps.

STAFFORDSHIRE IRON AND STEEL INSTITUTE. Proceedings. Vol. XXVI. Stourbridge, 1911. (Exchange.)

DIE STRÖMUNG IN RÖHREN UND DIE BERECHNUNG WEITVERZWEIGTER LEITUNGEN UND KANÄLE. By Viktor Blaess. München-Berlin, 1911. (Purchase.)

—— Atlas.

SURFACE WATER SUPPLY OF THE UNITED STATES, 1909. Part XI.—California. (Water Supply Paper No. 271, U. S. Geological Survey.) Washington, 1911. (Exchange.)

—— 1910. Part VIII.—Western Gulf of Mexico. (Water Supply Paper No. 288, U. S. Geological Survey.) Washington, 1911. (Exchange.)

TECHNOLOGY AND INDUSTRIAL EFFICIENCY. New York, McGraw-Hill Book Co., 1911. (Purchase.)

TONINDUSTRIE KALENDER, 1912. Pts. 1–3. Berlin, 1911. Gift of *Tonindustrie Zeitung.*)

UNION OF SOUTH AFRICA. MINES DEPARTMENT. Annual Report, 1910. Pts. 1–2. Pretoria, 1911. (Gift of South Africa Mines Department.)

U. S. CHIEF SIGNAL OFFICER. Report of, 1911. Washington, 1911. (Gift of U. S. War Dept.)

U. S. CIVIL SERVICE COMMISSION. Annual Report, 27th. Washington, 1911. (Gift of Civil Service Commission.)

U. S. ISTHMIAN CANAL COMMISSIÓN. Annual Report, 1911, with accompanying maps and diagrams. Washington, 1911. (Gift of Isthmian Canal Commission.)

U. S. LIBRARY OF CONGRESS. Report of the Librarian, 1911. Washington, 1911. (Exchange.)

U. S. NATIONAL MUSEUM. Proceedings. Vol. 40. Washington, 1911. (Exchange.)

USE OF PEAT FOR FUEL AND OTHER PURPOSES. (Bulletin No. 16, Bureau of Mines.) Washington, 1911. (Exchange.)

VAN NOSTRAND'S CHEMICAL ANNUAL, 1909. Edited by J. C. Olsen. New York, Van Nostrand Co., 1909. (Purchase.)

WATER RESOURCES OF ANTELOPE VALLEY, CALIFORNIA. (Water Supply Paper No. 278, U. S. Geological Survey.) Washington, 1911. (Exchange.)

WESTERN AUSTRALIA. GEOLOGICAL SURVEY. Annual Progress Report, 1910. Perth, 1911. (Gift of Government Geologist.)

WESTERN AUSTRALIA. MINES DEPARTMENT. Report, 1910. Perth, 1911. (Exchange.)

GIFT OF HILL PUBLISHING CO.

ALLOUEZ MINING CO. Report of the Directors to the Stockholders, 1908. Boston, 1908.

ASSOCIAZIONE MINERARIA SARDA. Anno XII., No. 1. Iglesias, 1907.

AUSTRALIA. COMMONWEALTH BUREAU OF CENSUS AND STATISTICS. Trade and Customs and Excise Revenue, 1906. Pt. II. Sydney, 1906.

——— Annual Statement of the Trade of the Commonwealth of Australia, 1904. Sydney, 1904.

AUSTRIA. K. K. Ackerbau Ministeriums. Statistisches Jahrbuch, 1904. Pt. 2. Wien, 1905.

——— K. K. Handelsministerium. Statistik des Auswärtigen Handels. 1905. Vol. III. Wien 1906.

——— K. K. Revierbergamte in Mähr. Ostrau. Katalog des Museums fur Unfallverhütung im Bergbau. Wien, 1911.

BROKEN HILL PROPRIETARY CO. Reports and Statements of Accounts for half year ending May 31, 1911. Australia, 1911.

BROKEN HILL SOUTH SILVER MINING CO. Reports, Statements of Accounts, for half year ended June 30, 1910. Melbourne, 1910.

CANADA. CUSTOMS DEPARTMENT. Tables of the Trade and Navigation, 1906. Ottawa, 1906.

DALY WEST MINING CO. Report, 1908. Salt Lake City, 1908.

DOUGLAS COPPER CO. Annual Report, 6th, 1909. New York, 1909.

GRENET, L. Trempe, Recuit, Cémentation et Conditions d'emploi des Aciers. Paris, 1911.

ITALY. Ministero delle Finanze. Statistica del Commercio Speciale. Dec., 1905; Oct.-Dec., 1906; Dec., 1907. Roma, 1906–1907.

——— Ministero di Agricoltura, Industria e Commercio. Rivista del Servizio Minerario, 1904, 1905. Roma, 1905–1906.

KINGSTON (ONT.) Calendar of the School of Mining, 1911–1912. Kingston, 1911.

LEANING, J. Quantity Surveying. Ed. 5. Lond.-N. Y., 1904.

MEXICO. Boletin de Estadistica Fiscal. No. 285. Mexico, 1906.

MEXICO. SECRETARIA DE FOMENTO, COLONIZACION E INDUSTRIA. Anuario Estadistico de la Republica Mexicana, 1904. Mexico, 1906.

MINES OF THE TRANSVAAL. Ed. 6. By R. R. Mabson. London, n. d.

MOODY'S MANUAL OF RAILROADS, 1908. New York, 1908.

NEW SOUTH WALES. MINES DEPARTMENT. Annual Report, 1910. Sydney, 1911.

NEW ZEALAND. GOVERNMENT STATISTICIAN'S OFFICE. Statistics of the Dominion of New Zealand, 1909. Vols. 1 2. Wellington, 1910.

NORWAY. STATISTISKE CENTRALBUREAU. Statistisk Aarbog for Kongeriget Norge, 1906. Kristiania, 1906.

——— Norges Handel, 1905. Kristiania, 1904.

OBERSCHLESISCHEN BERG UND HÜTTENMANNISCHEN VEREIN. Statistik der Oberschlesischen Berg und Hüttenwerke, 1906, 1907. Kattowitz, 1907, 1908.

OSCEOLA CONSOLIDATED MINING CO. Report, 1908. Boston, 1909.

QUINCY MINING CO. Report of the Directors to the Stockholders, 1908. Boston, 1908.

SKINNER, W. R. Mining Manual, 1910. London, 1910.

SOUTH AUSTRALIA. Mines Minister. Review of the Mining Operations, No. 13, Dec. 31, 1910. Adelaide, 1911.

SOUTH AUSTRALIA. Statistical Register of the State, 1905. Pt. III. Production. N. p., 1906.

SPAIN. MINISTERIO DE FOMENTO. Estadistica Minera de España, 1905. Madrid, 1906.

STATISTIQUE DE L'INDUSTRIE MINERALE ET DES APPAREILS À VAPEUR EN FRANCE ET EN ALGERIE, 1905. Paris, 1906.

SVERIGES OFFICIELLA STATISTIK. Kommerskollegii (C) Bergshandteringen, 1905, 1910. Stockholm, 1906, 1911.

——— ——— (F) Handel. 1905. Stockholm, 1906.

TAMARACK MINING CO. Report of the Directors to the Stockholders, 1908. Boston, 1909.

UNIVERSITY OF KANSAS. General Catalogue, 1910–1911. Lawrence, 1911.

UNIVERSITY OF UTAH. Catalogue, 1911–1912. Salt Lake City, 1911.

VEREINIGTE KÖNIGS-UND LAURAHÜTTE AKTIEN GESELLSCHAFT FUR BERGBAU UND HÜTTENBETRIEB. Bericht uber das Geschäftsjahr, 1910–1911. N. p., n. d.

VICTORIA. Mines and Water Supply. Annual Report, 1905. Melbourne, 1905.

WESTERN AUSTRALIA. Government Statistician's Office. Statistical Register, 1905. Pt. VII. Perth, 1907.

WESTERN AUSTRALIA. Supplement to Government Gazette. Mining Statistics, Dec., 1906. Perth, 1907.

TRADE CATALOGUES.

INGERSOLL-RAND CO., New York, N. Y.
Catalogue B-104. Rock-drills. 4 pages.
Catalogue B-105. Rock-drills. 4 pages.

NEW YORK LEATHER BELTING CO., New York, N. Y. *Phœnix*, Dec., 1911. A journal devoted to the interests of belt engineering. 18 pages.

United Engineering Society Library.

OKLAHOMA GEOLOGICAL SURVEY. Preliminary Report on the Road Materials and Road Conditions of Oklahoma. (Bulletin No. 8.) Norman, 1911. (Gift of Oklahoma Geological Survey.)

MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of December, 1911.

Members.

CHANCE, EDWIN M., Chem....Pottsville, Pa.
COX, GUY H., Teaching and Mining....Rolla, Mo.
CUELLAR, SALVADOR, Min. Engr....403 Calle Ojenaga, Chihuahua, Mexico.
DUCK, GEORGE F., Western Editor, *Mines and Minerals*, 1221 First National Bank Bldg., Denver, Colo.
EARLING, ROY B., Min. Engr....Ray, Ariz.
GAYFORD, ERNEST, Met....159 Pierpont St., Salt Lake City, Utah.
GOODE, EWART N., Met....Port Kembla, N. S. W., Australia.
HERRMANN, CHARLES E., Iron-Ore Miner and Shipper, 17 Battery Pl., New York, N. Y.
KO, SOKICHI, Prof. Econ. Geol....Kiushiu Univ., Fukuota, Japan.
LA CROIX, MORRIS F., Min. Engr....Ishpeming, Mich.
MANSFIELD, MELVIN, Min. Engr. and Assayer, 139 East So. Temple St., Salt Lake City, Utah.
MONTGOMERY, ERNEST A., Mine-Owner and Mgr., 409 Columbia Trust Bldg., Los Angeles, Cal.
RADCLIFFE, ALFRED, Met....Copiapo, Chile, So. Am.
ROEBER, E. F., Editor, *Metallurgical and Chemical Engineering*, 239 W. 39th St., New York, N. Y.
ROGERS, WILLIAM B., Min. Engr....64 Wall St., New York, N. Y.
SQUIRES, HOWARD W., Min. Engr....2007 Ocean View Ave., Los Angeles, Cal.

Associate.

STILLMAN, JAMES S., Secy. and Treas., Empire Steel & Iron Co., Catasauqua, Pa.

CANDIDATES FOR MEMBERSHIP.

The following persons have been proposed during the month of December, 1911, for election as members of the Institute. Their names are published for the information of members and associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Council, which has the power of final election.

Members.

Charles Homer Baxter, Loretto, Mich.
Proposed by Elwin F. Brown, O. C. Davidson, William Kelly.
Born, Feb. 12, 1879, at Detroit, Mich. 1898–1899, with Mason L. Brown, C.E., Detroit, Mich. 1899–1902, Mich. College of Mines, B.S., E.M. 1902-1903, Asst. Min. Engr., Quincy Min. Co., Hancock, Mich. 1903–1904, Min. Engr., Republic Iron & Steel Co., Negaunee, Mich. 1904–1905, Engr. for Dickinson County Board of County Commissioners, Iron Mountain, Mich. 1905–1906, Instructor in Civ. and Min. Engr., Mich. College of Mines, Houghton, Mich. 1907, Field Engr. for Jones Exploring Co., in Arizona and Utah.
Present position : 1907 to date, Supt., Loretto Iron Co.

Robert Hardy Bedford, Min. Engr., Grass Valley, Cal.
Proposed by A. D. Foote, William Hague, Arthur B. Foote.
Born, Nov. 19, 1882, at Kaikoura, New Zealand. 1901–1904, Univ. of N. Z. 1906, B.S Univ. of Mo.; 1911, E.M. 1906–1907, American Min. Engr. Co., Joplin, Mo. 1908–1910, Old Dominion Copper Min. Co., Globe, Ariz. 1910–1911, surveying, North Star Mines Co., Grass Valley, Cal.
Present position: Asst. Supt., North Star Mines Co.

Quincy Bent, Sparrows Point, Md.
Proposed by Charles F. Rand, James Gayley, C. Kirchhoff.
Born, July 28, 1879, at Steelton, Pa. 1901, Grad. Williams College, B.A. 1901–1902, Engr. on experimental work, Penn. Steel Co., Steelton, Pa. 1902–1909, Mgr. Penn. Steel Co.'s works at Lebanon, Pa., and Supt. of Construction, Cornwall Ore Bank Co., Lebanon, Pa.
Present position: Asst. to Pres., Maryland Steel Co.

Harry Scott Braman, Youngstown, Ohio.
Proposed by C. S. Robinson, W. E. Manning, John Birkinbine.
Born, Dec. 10, 1879, at Terre Haute, Ind. High School, Terre Haute. 1899–1903, Rose Polytechnic, M.E. 1903, Ohio Works, Carnegie Steel Co. 1907, Supt. Blast-Furnace, Youngstown Sheet & Tube Co.
Present position: Supt. Blast-Furnaces and Steel Dept., Youngstown Sheet & Tube Co.

James Bonnyman, Birmingham, Ala.
Proposed by George G. Crawford, T. H. Aldrich, Jr., Richard Peters, Jr.
Born, July 9, 1879, at Lexington, Ky. 1892–1897, Ky. State College (now Ky. State Univ.), Lexington, Ky. 1897, rodman, Govt. Engr. Corps. 1897–1899, weighman, timekeeper, engr. and Asst. Supt., Durham Mines, Pittsburg, Pa. 1899–1900, Engr., Chatta., Rome & So. R. R. Co., Rome, Ga. 1900, Supt., Durham Coal-Mines. 1900–1901, Road Master and Ch. Engr., C., R. & S. R. R. Co. 1901–1902, Supervisor, Central of Ga. Ry., who bought C., R. & S. R. R. 1902–1904, Supt. and Engr., Stearns Coal Co., Stearns, Ky. 1904, prospecting mineral properties, personal account. 1904–1905, Ch. Eng., Ga., Fla. & Ala. R. R., Bainbridge, Ga. 1905–1906, Asst. Engr., Cent. of Ga. R. R., Savannah, Ga. 1906, with Birmingham Coal Co., as Treasurer, Actg. Mgr. and Treas, Gen. Mgr. and Treas., Receiver and Trustee.
Present position: Vice-Pres. and Treas., Birmingham Coal Co.

Lawrence Ripley Clapp, Silverton, Colo.
Proposed by Franklin Guiterman, D. W. Brunton, F. J. Siebert.
Born, Feb. 25, 1884, at Brooklyn, N. Y. 1903–1905 and 1908–1910, School of Mines, Columbia Univ. M.E. 1905–1907, Chem., Cananea Copper Co. 1907, Sampler, Federal Lead Co. 1907–1908, Chem., Minas Tecolotes y Anexas. 1910–1911, Supt., Hda. de Louto, Pachuca, Mex.
Present position: Asst. Supt., Silver Lake Mines.

Roy LeGrand Cornell, 299 Mission St., Santa Cruz, Cal.
Proposed by Millard K. Shaler, Sydney H. Ball.
Born, July 22, 1881, at Summertown, Tenn. 1900, Assayer, Big Five Co., Frances, Colo. 1902, Underground, Independence, Cripple Creek, Colo. 1903, Chem. and Met., Troy-Manhattan Copper Co., Troy, Ariz. Entered Min. Dept. Univ. of Ariz. 1904, summer, Cananea Cons. Copper Co., Cananea, Mex. 1904–1906. College of Mines, Univ. of Cal. 1906–1907, Assayer, Mayflower Cons. Min. Co., Ryolite, Nev. 1907–1908, Operated in Nev., personal account. 1909, Surveying, Chafey Mines Co., Chafey, Nev. 1910. Engr. office, Battle Mountain, Nev.
Present position: with Société Internationale Forestière et Minière du Congo, Kanwa, via Banalia, Congo Belge, W. Africa.

Walter Marshall Dake, Jr., Fairview, Mich.
Proposed by E. E. Carpenter, E. Gybbon Spilsbury.
Born, Oct. 15, 1886, at Nashville, Tenn. 1904–1905, Rodman, chainman, instrument-man, Animas Power Co., Silverton, Colo. 1905–1906, Nashota Milling Co., Silver Plume, Colo. 1906–1907, Instrument-man for W. B. Milliken, Rhyolite, Nev. 1907, Assayer, Independant Smelter Co., Golden, Colo. 1908,

Assayer, San Juanis Reduc. Co., San Antonio, Baja, Cal. 1908–1909, Sampler and Foreman, El Vallé Mines Co., San Antonio, Baja, Cal. 1909, Smelter Foreman, El Valle Mines Co. 1910–1911, Filterman, table-man, Chile-mill man, solution-man for Goldfield Cons. Mill. Co.
Present position: Foreman, Nevada Hills Mill.

W. W. Davis, Leadville, Colo.
Proposed by D. W. Brunton, J. W. Finch, W. F. B. Berger.
Born, Feb. 10, 1863, at Decatur, Ill. 1886–1889, Scientific Dept., State Univ. of Kansas. Summers, field engr. with U. S. Geol. Survey. 1889–1891, Asst. Astronomer, U. S. Coast and Geod. Survey. Obtained LL.B. and LL.M. from Columbian Univ., Washington, D. C. 1896, returned to scientific work in connection with the operation of mines in Leadville, Colo., the principal one of which was the Yak Min., Mill. & Tunnel Co., August R. Meyer, Pres. 1899, became Vice-Pres. and Gen. Mgr., above company, also mgr. in charge of other mining companies in Leadville. Member of Colo. Scientific Society.
Present position: Vice-Pres. and Gen. Mgr., Yak Min., Mill. & Tunnel Co.; Gen. Mgr., Smuggler Leasing Co., Aspen, Colo.

Reginald B. Gerhardt, Felton, Oriente, Cuba.
Proposed by James E. Little, Charles F. Rand, Jennings S. Cox, Jr.
Born, Aug. 2, 1884, at Martinsburg, W. Va. Early education in public schools of Harrisburg, Pa. Penna. State College. 1907, Grad., Cornell Univ. Five years with the Penn. Steel Co., in electrical work; three years with the Spanish-American Iron Co., Cuba, in mining and metallurgical work.
Present position: Mech. Engr., Spanish-American Iron Co.

George Herbert Gibbs, Glan y mor, Baglan, Britton Ferry, S. Wales.
Proposed by Arnold K. Reese, J. Spencer Hollings, R. A. Hadfield.
Born, Feb. 19, 1879, at Burslem, Staffordshire, England. Educated up to 1892 at National and Wesleyan High Schools, Burslem. 1897–1899, Burslem and Manchester Tech. Schools. 1892–1899, training as engr. with Leigh & Simpson, 6 mos.; Kent Bros., 18 mos.; George & Abbey, 9 mos.; Shelton Steel Works, 12 mos.; Kerr, Stuart & Co., 6 mos. 1899–1901, Draftsman and Engr., Shelton Iron & Steel Co. 1901, Sheepbridge Coal & Iron Co. 1902, Midland Coal, Coke & Iron Co.; Graham, Morton & Co., Leeds 1902–1903, Ebbw Vale Iron & Steel Works. 1903–1907, Earl of Dudley's Steel Works. 1907–1908, Inspect. Engr. 1908–1909, Carnforth, Hermatite Furnaces.
Present position: Engr. to Albion Steel Co., Ltd.

Archie H. Jones, Tonopah, Nev.
Proposed by Frederick Bradshaw, W. W. Charles, A. R. Parsons.
Born, Mar. 3, 1873, at Davenport, Iowa. 1901–1904, Mill foreman, Smuggler Union Cyanide Plant, Telluride, Colo. 1904–1907, Supt., Dorcas Mill, Florence, Colo.
Present position: 1908 to date, Supt., Belmont Milling Co., Millers, Nev.

Richard Vincent McKay, Steelton, Pa.
Proposed by James E. Little, Charles F. Rand, Jennings S. Cox, Jr.
Born, Oct. 17, 1884, at Milton, Mass. 1901, Grad. Milton High School. 1906, S.B., Mass. Inst. Tech. 1906–1907, Blast-Furnaces, Penn. Steel Co., Quincy Bent., Mgr.; 1907–1909, Foreman, Steelton Plant. 1909–1911, Asst. Supt., Blast-Furnaces, Steelton. Jan.–May, 1911, Employed by Spanish-American Iron Co., Felton, Cuba, in nodulizing-work.
Present position: Supt., Blast-Furnace Dept., Pennsylvania Steel Co., Steelton, Pa.

Charles McKinnis, Wallace, Idaho.
Proposed by Horace V. Winchell, F. T. Greene, W. B. Fisher.
Born, Mar. 19, 1875, at Mirabile, Caldwell Co., Mo. 1896, Night mill-foreman, Silver King Mill, Wardner, Ida., for leasing company. 1896, Mill-man, Stemwinder Mill, Wardner, Ida., for Joe Branscomb, leaser. 1899–1901, Mgr., Copper King Min. Co., Seven Devils district, Ida. 1906–1912, Mgr., Sec. and Treas., also large owner, National Copper Min. Co., Mullan, Ida. 1907–1912, Mgr., Sec., Treas. and large owner, Caledonia Min. Co., Wardner, Ida.

Fred W. McNair, Houghton, Mich.
Proposed by William Kelly, F. W. Denton, M. M. Duncan.
Born, Dec. 3, 1862, at Fennimore, Wis. Grad. Univ. of Wis. Post-grad. work at Univ. of Wis., and Univ. of Chicago. Has been engaged mostly in engineering education. Field-work illustrated by articles like "Divergence of Long Plumb Lines at the Tamarack Mine," *Eng. and Min. Journal*, Apr. 26, 1902; "The Air from a Hydraulic Compressor," *Mining World*, Jan. 28, 1911.
Present position: President, Mich. College of Mines.

Frank Albert Metcalf, Wardner, Idaho.
Proposed by Rush J. White, Horace V. Winchell, F. L. Sizer.
Born, July 22, 1882, at Bardolph, Ill. 1903, Engr. Dept., Cornell College, Mt. Vernon, Iowa. 1906, B. & B. Dept. of C., M. & St. P. R. R., Marion, La.; transferred to Engr. Dept. at Minneapolis, Minn. Sent West as Engr. on Location in Wash. 1907, with Henry M. Lancaster, Min. Engr., Wallace, Idaho. June 15, 1906, C.E., Cornell College. 1910, Mech. Draftsman for Cœur d'Alène Iron Works, Wallace, Idaho., James Taylor, Mgr. 1911, Asst. Engr., Federal Min. & Smelt Co.
Present position: Asst. Engr., Last Chance Mine, Federal Min. & Smelt. Co., Wardner, Idaho.

John Forrest Orr, 149 Broadway, New York.
Proposed by S. A. Dockery, Frederick P. Burrall, H. S. Emlaw.
Born, Sept. 5, 1873, at Addison, N. Y. 1895, B.S., E.M., Mich. Min. School. 1895–1896, Min. Engr., Conchinyo, Chih., Mex. 1896–1897, Prof. Min. Engr., College of Mont. 1898–1900, Asst. Supt., Cyanide Plant, Triunfo, B. C., Mex. 1900–1902, Supt., Cyanide Plant, Corrigan, McKinney & Co., Ropes Gold Mine, Mich., and Conchinyo, Chih., Mex. 1902–1903, with Penobscot Min. Co., Maitland, S. D. 1903–1905, Independent work in Mex. 1905–1907, with Colo. Min. Co., Ceno Colorado, Son., Mex. 1907–1911, Engr. and Salesman, Chalmers & Williams.
Present position: Eastern Mgr., Chalmers & Williams, Inc.

Seeley Benedict Patterson, Jr., 19 Flood Block, Anaconda, Mont.
Proposed by J. F. Kramer, S. B. Patterson, C. D. Demond.
Born, June 6, 1885, at Quinnimont, W. Va. 1902–1904, Columbia Univ., School of Mines. 1906, Grad., Colo. School of Mines. 1906–1907, with Robesonia Iron Co., Ltd., Robesonia, Pa. 1907–1908, Asst. Civil Engr., Spanish-American Iron Co., Daiquiri, Cuba. 1908–1910, Spanish-American Iron Co., Mayari, Cuba. 1910, Laboratory and Test Dept., Anaconda Cop. Min. Co.
Present position: Testing Dept., Washoe Plant, Anaconda Cop. Min. Co.

William Clifton Phalen, Washington, D. C.
Proposed by George Otis Smith, E. W. Parker, David T. Day.
Born, Feb. 1, 1877, at Gloucester, Mass. 1899. S.B., Mass. Inst. Tech., Boston, Mass.; 1902, S.M. 1909, Ph.D., George Washington, Univ., Washington, D. C. 1899–1901, with New Mex. School of Mines., Socorro, N. M 1902–1904, Division of Geol., U. S. Nat. Museum. 1904–1907, Geol. Aid, U. S. Geol. Survey.
Present position: 1907 to date, Asst. Geol., U. S. Geol. Survey.

Luis Emlynn Salas, New York, N. Y.
Proposed by Arthur L. Walker, Robert Peele, Henry S. Munroe.
Born, Dec. 7, 1876, at London, Eng. Queen's Scholarship to Borough Road College, Richmond, Isleworth. 1904, B.S., London Univ. 1910, M.A., Columbia Univ., New York. Nine years in chemical work in London, part of time studying under Dr. Mills (Tubingen Univ.). Three years Anal. Chem. of Mexican company in Coahuila. Anal. Chem. and Assayer, Torreon, Mex.
Present position: Representative Chem. in N. Y. City to the Cia. Exploradora Coahuileuse, Mex.

Charles Joseph Stakel, Ishpeming, Mich.
Proposed by M. M. Duncan, E. E. White, J. E. Jopling.
Born, Mar. 3, 1883, at Menominee, Mich. 1905, Grad. Mich. College of Mines, M.E. 1905–1906, Asst. Engr., Ashland Mine, Cleveland-Cliffs Iron Co., Ironwood, Mich. 1906–1910, Min. Engr., C. C. I. Co., on Marquette Range. 1910–1911, in charge concrete shaft, Negaunee mine, for C. C. I. Co.
Present position: Asst. Ch. Engr., Cleveland-Cliffs Iron Co.

Ralph D. Van Valkenburgh, 213 West Lake St., Chicago, Ill.
Proposed by Robert E. Jennings, Henry D. Hibbard, John Rice.
Born, Mar. 1, 1877, at Greene, Chenago Co., N. Y. Greene Union High School. 1901, Grad. Cornell Univ. 1901–1906, Draftsman, Ch. Draftsman and Ch. Engr., Gifford Bros., Hudson, N. Y., elevating and conveying mchy., and for some time operators of Copake Iron Works. 1906–1907, Draftsman and squad boss, Jeffrey Mfg. Co., Columbus, Ohio. 1907–1909, Ch. Engr., H. W. Caldwell & Son Co., Chicago, Ill. 1909–1911, Branch Mgr., Taylor Iron & Steel Co., High Bridge, N. J.
Present position: Western Mgr., Colonial Steel Co., Pittsburg, Pa.

Gustavus R. Waeber, Iron River, Mich.
Proposed by Felix A. Vogel, Charles E. Lawrence, Elwin F. Brown.
Born, Oct. 14, 1880, at Hoboken, N. J. 1898–1900, Chem. Technikum, Burgdorf, Switz. 1900–1903, Polytechnikum, Zurich, Switz. 1903–1905, Chem., Davis Baking Powder Co., Hoboken, N. J. 1906–1908, Mine Chem., St. Lawrence Pyrites Co., Hermon, N. Y., office, 25 Broad St., New York. 1908–1909, Chem., Hartford Laboratory Co., Hartford, Conn. 1909, Chem., Florence Iron Co., Florence, Wis. 1909–1910, Chem., N. Y. State Steel Co., Virginia, Minn.
Present position: Independent Chemist.

Henry Stuart Weigall, Kapsan Min. Concession, via Songchin, China.
Proposed by A. R. Weigall, F. Danvers Power.
Born, Dec. 4, 1880, at Sydney, N. S. W. 1903, Grad., Univ. of Sydney, B.E. 1903, General underground experience with Hillgrove Proprietary Mines, Ltd., Hillgrove, N. S. W. 1904, Assayer, Aust. Min. & Gold Recovery Co., Cyanide Works, Hillgrove. 1905, Asst. Mgr., N. Danvers Power, Mgr. 1906, Asst. to Ch. Engr., Manchu Synd., Ltd., of London and Seoul, Korea, examination and development of mines in Korea and Manchuria. 1907–1908, Asst. to Ch. Engr., Collbran-Bostwick Dev. Co., of Hartford and Seoul, Korea, in charge of development at Kang Neung, Korea. 1908–1909, Actg. Mgr., Seoul Min. Co., Suan Mine, Korea. 1909–1911, Asst. Mgr., Collbran-Bostwick Dev. Co., Kapsan Min. Concession, Korea.
Present position: In charge of prospecting and development of all outside mines in above concession.

O. W. Wheelright, Florence, Wis.
Proposed by Felix A. Vogel, E. Gybbon Spilsbury, C. K. Leith.
Born, June 18, 1882, at Belleville, Wis. 1900–1904, Univ. of Wis. 1904, A.B. 1906–1909, Grad., Geol., Univ. of Wis. 1907, summer, Miss. Bureau of Geol. and Mines. 1908, summer, Geol. work on Menominee Range, Mich., under C. K. Leith and R. C. Allen. 1909, summer, Geol. work on Menominee Range, under C. K. Leith. Oct.–Nov., 1909, Geol. Work, Mich. Geol. Survey, R. C. Allen, Director.
Present position: Geol. for Florence Iron Co., and Florence Exploration Co., Felix A. Vogel, Gen. Mgr.

Lowe Whiting, Iron River, Mich.
Proposed by Felix A. Vogel. E. Gybbon Spilsbury, Charles E. Lawrence.
Born, Sept. 25, 1873, at St. Paul, Minn. 1895, Degree of Engr. of Mines, Columbia College, and have followed this profession to the present time.
Present position: Supt., Bates Iron Co.

John Byron Wilson, Wallace, Idaho.
Proposed by Horace V. Winchell, F. L. Sizer, Rush J. White.
Born, Feb. 10, 1880, at Dayton, Wash. 1905–1907, Asst. City Engr., Walla Walla, Wash. 1907, with Level Party, U. S. Geol. Survey, Utah, and Nev., T. A. Green, Chief.
Present position: 1908 to date, Engineer, Federal Min. & Smelt. Co.

CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the month of December, 1911. This list, together with the foregoing list of new members and the lists printed in *Bulletin* Nos. 50 to 60, therefore, supplements the annual list of members corrected to Jan. 1, 1911, and brings it up to the date of Jan. 1, 1912.

ADAMS, ARTHUR K..............................General Land Office, Los Angeles, Cal.
ATWATER, RICHARD M., JR., Ladenburg, Thalmann & Co., 25 Broad St., New York, N. Y.
BOORAEUM, ROBERT E......................................Union Club, New York, N. Y.
BORDEAUX, ALBERT F. J., Care Bryner, Kousnetzoff & Co., Vladivostok, Siberia.
BRADLEY, OLIVER U..........................725 Flynn-Ames Bldg., Muskogee, Okla.
BRADLEY, WALTER W., Care Calif. State Mining Bureau, Ferry Bldg., San Francisco, Cal.
BREWER, ARTHUR K.................................1408 Baker St., San Francisco, Cal.
BRINSMADE, ROBERT B., Cons. Engr......... ....Apartado 185, Puebla, Mexico.
CALDWELL, HALSTED W.......................................Instructed to hold all mail.
CAYPLESS, WILLIS S., Care American Smelting & Refining Co., Aguascalientes, Mexico.
CHISHOLM, JOHN, Care D. C. Stapleton, Anglo-Colombian Dev. Co., Ltd., Buenaventura, Colombia, So. Am.
CLEAVELAND, NEWTON, Genl. Mgr., Natomas Cons. of Calif., Alaska-Commercial Bldg., San Francisco, Cal.
COX, W. RAY...Flat River, Mo.
DAVIS, FRANK S..Glenwood Springs, Colo.
DE LASHMUTT, IVAN..Nelson, B. C., Canada.
DEL MAR, ALGERNON...So. Pasadena, Cal.
DENNIS, FRANCIS J....................................2054 Central Ave., Alameda, Cal.
DIXON, JAMES T...Instructed to hold all mail.
EAGAN, CHARLES E..Instructed to hold all mail.
EATON, HUBERT L...117 Colonial Apts., Reno, Nev.
EMLAW, HARLAN S., Care Abangarez Gold Fields, Puntarenas, Costa Rica, C. A.
EMMONS, N. H., Cons. Engr........................921 Temple Ave., Knoxville, Tenn.
ERDLETS, JOSEPH F. B., JR............................52 Broadway, New York, N. Y.
FORBES, D. L. H., Min. and Met. Engr., 306 Mining Chambers, Toronto, Ont., Can.
GRANSTROM, GUSTAF A., Min. Engr..Sala, Sweden.
GROVE, INDEPENDENCE...................Amparo Mining Co., Etzatlan, Jal., Mexico.
GUESS, GEORGE A..Napanee, Ont., Canada.
HADFIELD, SIR R. A..... ....22 Carlton House Terrace, London, S. W., England.
HAGAR, EDWARD McK., Universal Portland Cement Co., 72 W. Adams St., Chicago, Ill.
HAWXHURST, ROBERT, JR., Care International Banking Corpn., 36 Bishopsgate St., London, E. C., Engand.
HOOVER, H. C.........................1 London Wall Bldgs., London, E. C., Engand.
HUMBERT, FRANK U...Low Moor, Va.
HYBINETTE, VICTOR......................Nickel Works, Christiansand, "S," Norway.
KIRKCALDY, N. M.......................................Kirchenfeld, Berne. Switzerland.
KLUGH, BETHUNE G...P. O. Box 382, Birdsboro, Pa.
LAMB, MARK R..................Mgr., Allis-Chalmers Co., Santiago, Chile, So. Am.
LANGLEY, SETH S..............................Bonanza, via Zimapan, Hid., Mexico.
LEWIS, GRENVILLE, Prest. and Genl. Mgr., Ideal Block Coal Co., Box 2, Lily, Ky.
LINDBERG, CARL O., Min. Engr., with W. R. Cox and staff, 527 Union League Bldg., Los Angeles, Cal.
LOW, V. F. STANLEY.............Airlie St., So Yarra, Melbourne, Vic., Australia.
McCANN, FERDINAND, Mgr.....El Tajo Mining Co., San Sebastian, Jal , Mexico.
McGEE, JOHN, Genl. Mgr.................United Greenwater Copper Co., Dale, Cal.
McILVAIN, EDWARD M., Prest., Lehigh Coke Co., 71 Broadway, New York, N. Y.
McINTOSH, JOSEPH B. S....................United Verde Copper Co., Jerome, Ariz.

MATHEWS, EDWARD J.........................1007 Hoge Bldg., Santa Monica, Cal.
MELZER, GUSTAV E., Cons. Min. Engr. and Met.....................Baker City, Ore.
MINSCH, WALTER C.....Guanajuato Reduction & Mines Co., Guanajuato, Mexico.
MUNRO, DUNCAN M......................Care Mina Bonanza, Zimapan, Hid., Mexico.
NAWATNY, WILLIAM F., Min Engr...Oakwood, Ill.
NICHOLAS, ASKIN M., Care C. E. Backer, 31 Queen St., Melbourne, Vic., Australia.
PLOCK, ALBERT F...Instructed to hold all mail.
RAHT, AUGUST..828 Emerson St., Denver, Colo.
RAMSAY, WILLIAM.........................Mgr. Wharton Coal & Coke Co., Coral, Pa.
READING, RICHARD W., Care Society of California Pioneers, 5 Pioneer Pl., San Francisco, Cal.
REED, DAVID C.................Avenida Terry 160, Barranco, Lima, Peru, So. Am.
RICE, EUGENE R...McNeil Hotel, Miami, Ariz.
RIGHTOR, FRED E., Office Engr.......Texas Bitulithic Co., Box 314, El Paso, Tex.
ROBBINS, CHARLES P...................................1134 3d Ave., Santa Monica, Cal.
SAMPSON, ROSWELL E....................................P. O. Box 187, Pullman, Wash.
SAYRE, MORTIMER F...................Croton Magnetic Iron Mines, Brewster, N. Y.
SEAMAN, HENRY B., Cons. Engr.......................165 Broadway, New York, N. Y.
SHARP, ALEXANDER.. ....2526 W. 7th Ave., Vancouver, B. C., Can.
SIRDEVAN, WILLIAM H., Hammond Laboratory, Yale Univ., New Haven, Conn.
STERLING, ROBERT R...1818 Ave. W., Seattle, Wash.
STINES, NORMAN C....................Care Otto Lagerfeld, Vladivostok, East Siberia.
VAN SLYKE, FREDERICK E.. ....4 Eslington Road, Newcastle-on-Tyne, England.
VIVIAN, GEORGE G.......................................1635 Albion Bldg., Denver, Colo.
WALLACE, H. VINCENT, Mgr., Mineral Development Co., Apartado 52, Guanajuato, Mexico.
WARNER, THOR................................P. O. Box 186, So. Porcupine, Ont., Can.
WHEELER, SHELTON K...... ....R. F. D. 2, Box 114, Billings, Mont.
WHITAKER, ORVILLE R...............................1577 St. Paul St., Denver, Colo.
WHITE, MARCUS...915 N. 20th St., Boise, Idaho.
WICKES, GEORGE T...................................The Helena Club, Helena, Mont.
WILMOTH, LESLIE J., Care Institute of Mining and Metallurgy, Salisbury House, London, E. C., England.
YORK, JAMES E...113 Montague St., Brooklyn, N. Y.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address of Record, from which Mail has been Returned.
Danforth, A. H.,	Cotopaxi, Colo.
Edwards, Robert L.,	P. O. Box 1673, Salt Lake City, Utah.
Fitzgerald, Thomas F. M.,	211 Sharon Bldg., Salt Lake City, Utah.
Furness, James W.,	Coffee, Trinity Co., Cal.
Goodloe, Meade,	So. Ariz. Smelting Co., Sasco, Ariz.
Hagemann, Wilhelm,	Metates, via Tepehuanes, Dur., Mexico.
Hawkins, Tancred,	Red Bandana Gold Mine, Elizabethtown, N. M.
Johnson, Dion L.,	325 Water St., Pittsburg, Pa.
Lampshire, John O.,	Vulture Mine, Wickenburg, Ariz.
Leavell, John H.,	Buffalo Mine, Cobalt, Ont., Canada.
McDougall, Wallace D.,	20 Bedford Place, Russell Sq., London, Eng.
Martin, Nicholas J.,	Wright & Callender Bldg., Los Angeles, Cal.
Mayer, Paul H.,	13 Central Park W., New York, N. Y.
Moore, Roy W.,	P. O. Box 48, Velasco, Tex.
Munroe, Martin,	Bengal Coal Co., Murulidih, Mohada, B. N. Ry., Bengal, India.
Nelson, D. W. C.,	Baker City, Ore.
Nobs, Frederick W.,	Negociacion Minera Santa Maria de Guadalupe y Anexas, S. A., Minillas, Zac., Mexico.
Pearson, William R.,	628 W. 114th St., New York, N. Y.
Perks, Harry B.,	419 Board of Trade Bldg., Portland, Ore.
Prentis, Edmund A., Jr.,	Lluvia Oro Mine, Lluvia de Oro, Chih., Mex,
Rathborne, Merwyn R. W.,	Amargosa, via Las Vegas, Nev.
Rhew, James W.,	Cia. Minera y Exploradora de Ventanas, S. A., Ventanas, Dur., Mex.
Sheldon, Waldo,	Urique, Chih., Mexico.

Short, Frank R., ... Carson City, Nev.
Thornton, Edward T., ... Apartado 30, Matehuala, S. L. P., Mexico.
Twynam, Henry, . . . O. K. Copper Mine, Cairns, No. Queensland, Australia.
Watson, Ralph W., ... Calloo, Utah, Clifton Mail box.
Weddle, Joseph H., ... 100 William St., New York, N. Y.

NECROLOGY.

The deaths of the following members were reported to the Secretary's office during the month of December, 1911:

Date of Election.	Name.	Date of Decease.
1887.	*Grubb, Charles B.,	November 12, 1911.
1890.	*Hesse, Conrad E.,	May 30, 1910.
1897.	*Matcham, Charles A.,	September 22, 1911.

* Member.

The Excursion to Hawaii and Japan.

(Following the San Francisco Meeting, October, 1911.)

BY R. W. RAYMOND, SECRETARY EMERITUS.

The Reception Committee in Japan.

Baron Shibusawa, *Chairman.*

Representing the Japanese Members of the Institute.

Masayuki Otagawa.
Benzo Katsura.
Reiji Kanda.
Shigema Yamanouchi.

Representing the Association of Mine Owners in Japan.

Tsunashiro Wada.
Kingo Nambu.
Takuma Dan.
Rokusaburo Kondo.

Representing the Mining Institute of Japan.

Rentaro Hotta.
Keisuke Kato.
Kageyoshi Noro.
Wataru Watanabe.

The Banquet Committee, Tokyo.

Viscount Kaneko and Baron Shibusawa, *Chairmen.*

Committee on Special Trains and Steamer.

Masayuki Otagawa.
Ritaro Hirota.
Kageyoshi Noro.
Otohiko Matsukata.
Tetsuo Ichiyoshi.
Reiji Kanda.
Motosada Zumoto.
Keijiro Nakamura.
Tetsutaro Hasegawa.
Tatsuya Kato.

List of Members and Guests Participating in the Excursion.

Miss Rebecca A. Adams, Orange, N. J.
Mr. and Mrs. H. Foster Bain, San Francisco, Cal.
Mrs. Rebecca B. Berger, Pittsburg, Pa.
Mr. George B. Berger, Pittsburg, Pa.
Mrs. John H. Boalt, San Francisco, Cal.
Mr. and Mrs. LeRoy Brewster, New York, N. Y.
Mr. David W. Brunton, Denver, Colo.
Mr. and Mrs. W. L. Clark, Jerome, Ariz.
Miss Lela Cole, Hayden, Ariz.
Miss Bertha S. Coyne, Philadelphia.
Mr. and Mrs. F. H. Daniels, Worcester, Mass.
Dr. and Mrs. Henry S. Drinker, So. Bethlehem, Pa.
Miss Aimee Ernesta Drinker, So. Bethlehem, Pa.
Miss Katherine Shober Drinker, So. Bethlehem, Pa.
Mr. C. F. Galan, San Luis Potosi, Mex.

Miss Mary Gillett, Westfield, Mass.
Mr. and Mrs. H. W. Goddard, Worcester, Mass.
Mr. Charles W. Goodale, Butte, Mont.
Mr. and Mrs. H. C. Greer, Morgantown, W. Va.
Miss Amanda Greer, Morgantown, W. Va.
Mr. Abbot A. Hanks, San Francisco, Cal.
Capt. and Mrs. R. W. Hunt, Chicago, Ill.
Mr. Reiji Kanda, Tokio, Japan.
Mr. and Mrs. Clement Le Boutillier, High Bridge, N. J.
Mr. and Mrs. W. R. McIlvain, Reading, Pa.
Mr. William McIlvain, Reading, Pa.
Mr. and Mrs. Walter B. Manny, New York, N. Y.
Mr. E. A. Montgomery, Los Angeles, Cal.
Mr. and Mrs. Willard S. Morse, New York, N. Y.
Mr. W. V. Morse, Maurer, N. J.
Mr. Seeley C. Mudd, Los Angeles, Cal.
Mr. and Mrs. Seeley W. Mudd, Los Angeles, Cal.
Mr. Jose Muriel, San Luis Potosi, Mex.
Mrs. Edward J. Price, Los Angeles, Cal.
Mr. and Mrs. T. H. Proske, Denver, Colo.
Dr. and Mrs. Rossiter W. Raymond, New York, N. Y.
Miss Susan Raymond, New York, N. Y.
Miss Lillian Reeves, Canal Dover, Ohio.
Prof. and Mrs. Joseph W. Richards, So. Bethlehem, Pa.
Miss Winifred Richards, So. Bethlehem, Pa.
Mr. W. L. Saunders, New York, N. Y.
Miss Jean Saunders, New York, N. Y.
Mr. and Mrs. F. C. Smink, Reading, Pa.
Miss Elizabeth Smink, Reading, Pa.
Dr. Joseph Struthers, New York, N. Y.
Mr. and Mrs. Edwin Thomas, Catasauqua, Pa.
Miss E. R. Thomas, Catasauqua, Pa.
Mr. A. E. Vaughan, New York, N. Y.
Mr. and Mrs. Eli Whitney, New Haven, Conn.
Miss E. F. Whitney, New Haven, Conn.
Miss F. P. Whitney, New Haven, Conn.
Major and Mrs. W. H. Wiley, New York, N. Y.
Mr. and Mrs. D. Williams, New York, N. Y.
Mr. and Mrs. Newton R. Wilson, Beaumont, Tex.
Mr. and Mrs. Philip Wiseman, Los Angeles, Cal.
Mr. P. Kenneth Wiseman, Los Angeles, Cal.
Mr. and Mrs. Otto C. Wolf, Philadelphia, Pa.
Mrs. Rudolph H. Wolf, Philadelphia, Pa.

Itinerary and Programme.

Nov. 3rd (Friday): Arr. Yokohama early morning.
Presentation of memorial medals by the Chamber of Commerce.
Lunch at the Grand Hotel.
3 p.m.: Reception by the City of Yokohama.
Lv. Yokohama 5.12 p.m. Arr. Tokyo 5.40 p.m. Stop at Imperial Hotel.
9 p.m.: Ball by the Minister of Foreign Affairs in honor of the Emperor's Birthday.

Nov. 4th (Saturday): Forenoon: Sightseeing. Visit to the Imperial University, Imperial Museum, and Art Exhibition.
Noon: Luncheon by the City of Tokyo at Hotel Seiyoken, Uyeno Park. Visits to Asagusa and Wrestling Hall.
7.30 p.m.: Dinner by the Reception Committee at the Imperial Hotel.

Nov. 5th (Sunday): Morning: Visit to the Military Museum and the Imperial Garden at Shinjuku.
Noon: Luncheon by the Mining Institute of Japan at the Maple Club.
3.30 p.m.: Reception at the Mitsui Club by the Minister of Agriculture and Commerce. Lv. Tokyo 10.50 p.m.

Nov. 6th (Monday): Arr. Kyoto 1.49 p.m. Stop at the Kyoto Hotel and the Miyako Hotel.

Nov. 7th (Tuesday): Sightseeing (including a visit to the old Imperial Palace). Luncheon at hotels.
Afternoon: Imperial University of Kyoto.
Evening: Dinner by City Officials at Commercial Museum.

Nov. 8th (Wednesday): Lv. Kyoto 8.10 a.m. Arr. Nara 9.36 a.m. Sightseeing.
Afternoon: Reception by Mayor.
Lv. Nara 4.25 p.m. Arr. Kobe 6.45 p.m. Dinner at Oriental Hotel.
Board the steamer *Umegaka-Maru* by 10 p.m. A launch will leave the American "Hatoba" three times between 8 and 10 p.m. Lv. Kobe at midnight.

Nov. 9th (Thursday): Arr. Shisaka Island 9 a.m.
Visit to Sumitomo Smelting Works.
Lv. Shisaka Island about noon. Arr. Miyajima 5 p.m. Sightseeing. Stay on board.

Nov. 10th (Friday):
During the morning: Sightseeing. Lv. Miyajima 3 p.m.

Nov. 11th (Saturday): Arr. Moji 7 a.m. Lv. Moji by steamer 8.30 a.m. Arr. Yawata 9 a.m.
Visit Imperial Steel Works. Lunch on board. Lv. Yawata 2.30 p.m. Arr. Moji 3.30 p.m.
6 p.m.: Banquet at the Moji Club by the Chiku-ho Coal Mining Association.
Lv. Moji at night, taking the 10.50 p.m. train from Shimonoseki.

Nov. 12th (Sunday): Arr. Kobe 2.35 p.m. Stop at the Oriental Hotel and the Tor Hotel.

Nov. 13th (Monday): Lv. Kobe 8.40 a.m. Arr. Osaka 9.34 a.m. Sightseeing.

Presentation of memorial medals by the City of Osaka and the Chamber of Commerce.

Lunch by Baron Fujita at his residence.

Lv. Osaka 1.30 p.m. Arr. Suma 2.38 p.m.

Garden Party by Baron Sumitomo.

Lv. Suma 5.35 p.m. Arr. Kobe 5.50 p.m. Stop at the Oriental Hotel and the Tor Hotel.

Nov. 14th (Tuesday): Lv. Kobe 8.05 a.m. Arr. Tokyo 10.32 p.m. Stop at Imperial Hotel.

Nov. 15th (Wednesday):

4 p.m.: Reception by the Tokyo Chamber of Commerce on the premises.

7 p.m.: Imperial Empire Theater. Theater Party by Baron Iwasaki, Baron Mitsui, and Mr. Furukawa, followed by supper in the theater.

Nov. 16th (Thursday): Lv. Tokyo (Uyeno Station) 10 a.m. Luncheon on train. Arr. Nikko 2.05 p.m. Stop at the Nikko Hotel and the Kanaya Hotel.

2.30 p.m.: Visit to the Copper Works of the Furukawa Mining Co.

Nov. 17th (Friday): Sightseeing at Nikko.

Nov. 18th (Saturday): Lv. Nikko 8 a.m. Arr. Ofuna 1.46 p.m.

At Ofuna, the party is divided into two sections, A and B.

SECTION A:

Nov. 18th (Saturday): Lv. Ofuna 1.50 p.m. Arr. Kamakura 2.01 p.m. Stop at Kaihin-in Hotel.
Sightseeing at Kamakura and Enoshima.

Nov. 19th (Sunday): Lv. Kamakura 8.15 a.m. Arr. Kodzu 9.14 a.m. Thence by the tram and rikisha to Miyanoshita. Stop at Fujiya Hotel, Miyanoshita.

Nov. 20th (Monday): Lv. Miyanoshita in time for the 8.35 a.m. train from Kodzu. Arr. Ofuna 9.17 a.m.

SECTION B:

Nov. 18th (Saturday): Lv. Ofuna 1.54 p.m. Arr. Kodzu 2.38 p.m. Thence by the tram and rikisha to Miyanoshita. Stop at Fujiya Hotel, Miyanoshita.

Nov. 19th (Sunday): Lv. Miyanoshita in time for the 9.25 a.m. train from Kodzu. Arr. Kamakura 10.20 a.m. Stop at Kaihin-in Hotel. Sightseeing at Enoshima and Kamakura.

Nov. 20th (Monday): Lv. Kamakura 9.05 a.m. Arr. Ofuna 9.14 a.m.

At Ofuna the two sections meet again.

Nov. 20th (Monday): Lv. Ofuna 9.22 a.m. Arr. Yokohama 9.58 a.m. Stop at Grand Hotel.

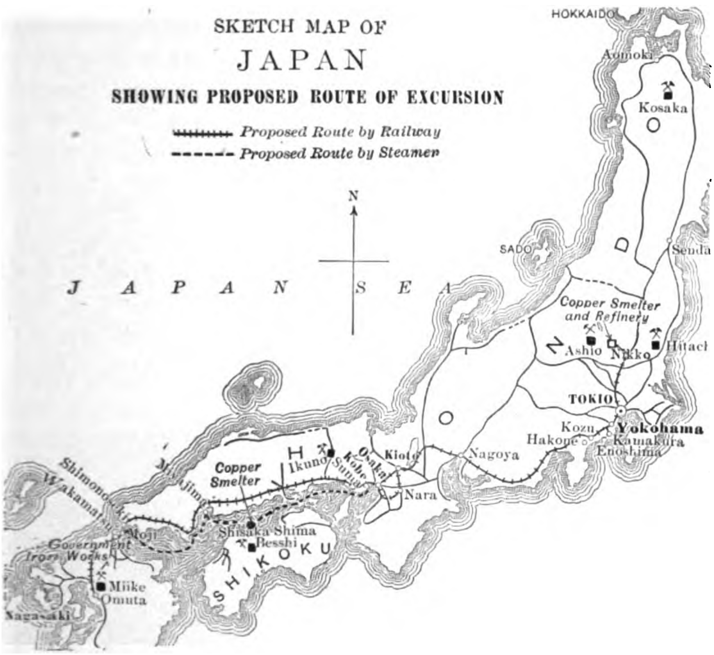


FIG. I.—MAP, SHOWING ROUTE OF EXCURSION.

On the Manchuria.

SOMEWHAT fatigued with excess of enjoyment and strenuous continuity of movement on the trip to and through California, the members and guests of the Institute party embarked Tuesday, Oct. 17, on the Pacific Mail S. S. *Manchuria* for a further journey to and through Japan. The good ship displayed the flag of the Institute (blue cross-hammers on a white ground), together with the Stars and Stripes and the ensign of the company.

Uninterrupted fair weather and smooth water attended the passage to Honolulu. The *Manchuria* proved herself most commodious, comfortable and clean ("A *sweeter* steamship never sailed," quoth President Hunt); Captain Dixon and his officers were most agreeable, as well as most efficient; the passenger list comprised many congenial people besides ourselves—among them a score of missionary folk, and also Mr. M. H. de Young, Vice-President of the Panama

Pacific International Exposition of 1915, who, accompanied by his wife and two daughters, was going to Asia as a Special Commissioner to interest the Oriental peoples, and secure their participation, in that great celebration; and the daily life on board soon became crowded with interesting events—an outline of which will be given later.

Sea and Sky.

The Pacific ocean more than justified its amicable name. It was not merely quiet, but brilliant and charming. Over its sparkling waters the steam-ship moved swiftly on even keel, surrounded by flashing waves of her own making, crested and laced with foam, a delicate embroidery upon the infinite blue depths. Near the California coast several whales were seen—part of a school of more than a hundred

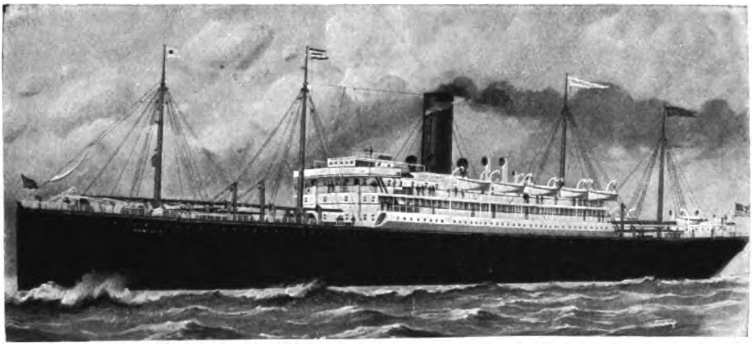


FIG. 2.—S. S. *Manchuria.*

which, as the Captain told us, had been playing up and down from Acapulco to Astoria for several weeks. Afterwards dolphins leaped in shining curves and porpoises rolled their black wheels, and flying-fish scurried and skittered in the sunshine. As we approached the islands strange land-birds flew around us, and sometimes rested upon our ship. But one sight, characteristic of a sea-voyage in earlier times, was entirely absent—the sight of another vessel. With the exception of the *Mongolia,* the sister-ship of the *Manchuria,* the lights of which we made out, as she passed us after dark, we saw between San Francisco and Honolulu, and again from Honolulu to Yokohama, not a single sail or smoking funnel. Of course we knew that this was the natural consequence of the disappearance of sailing

vessels from ocean lines of commerce and travel, and of the employment by their victorious steam-driven competitors of definite routes, precluding casual and unexpected encounters. "Ships that pass in the night" has been quoted as a symbol of regrettably brief acquaintances. But, in fact, ships had better pass than actually meet one another! And now that wireless telegraphy permits either ship to say whatever she wants to say, and still keep her distance, it is seldom that they take pains to come within sight of each other. Even the two sisters, the *Manchuria* and the *Mongolia,* after a ceremonious exchange of greeting-signals, went on their several ways without any attempt at conversation by the code. What need? They had electrically talked each other out long before they became mutually visible. It is difficult to realize how speedily and widely and radically wireless telegraphy has transformed the manners and customs of the sea. One has to accept with a grain of salt the stories of an old sailor; but Captain Dixon seemed to be telling the truth when he told us that the ships of the Pacific Mail, crossing and recrossing, ordinarily held no closer communication than that we had witnessed, unless one wanted to transfer to the other a "stowaway."

But the sky had its splendors, not less entrancing than those of the sea. The brilliancy of the stars at night was startling; and the glories of sunset and sunrise were such as are viewed far less frequently elsewhere. It is in the tropics that the clouds habitually mass themselves so grandly, and glow with colors so various and intense. On this voyage Venus shone as the morning star with extraordinary brightness, illumining sky and wave like a moon. And an epitome of celestial magnificence was furnished just before sunrise, on the way to Honolulu, when the morning star hung above the golden horizon, and a bright comet, with streaming tail, shone between, headed towards the coming sun. No one who arose early enough to catch that vision will ever forget it.

Honolulu.

Before our arrival at Honolulu, an aerogram from the Hawaiian Engineering Association invited our party to visit Pearl Harbor, which is being fortified by the United States; and a delegation from the society boarded the *Manchuria* as soon as she reached the dock. Invitations were also received from the Country Club and the Commercial Club of Honolulu. But plans previously made for our short stay necessitated the postponement of these friendly schemes until our return.

Arriving at 9.30 a.m., Monday, Oct. 23, we were conveyed in automobiles through the town and suburbs. It was quite warm in the city, though cooler and deliciously breezy outside. Nearly continuous rains for a week had prepared this bright, perfect "Institute" weather. The procession went to Pali, whence a superb panorama of sea and land was enjoyed; thence to the extensive park gardens and farms of Mr. Damon, and later to the polo-field, and along the side of a huge extinct crater, now full of brackish water. A visit was made to the Aquarium, which contains a notable variety of queer, beautiful and strangely-colored fish; and another visit to the Bishop Museum of Hawaiian and South Sea antiquities and curiosities. A typical Hawaiian lunch was had at the Moana Hotel, comprising, in addition to more familiar items, papaia, mullet in ti leaves, fried frogs' legs, taro cake, alligator pear and pineapple sherbet —the latter served in whole fresh pineapples. After lunch there was surf-bathing or watching the performances of the natives in the surf; shopping; further driving among the stately residences and grounds of the wealthy citizens, etc.; and at 5 p.m. the *Manchuria* sailed for Yokohama. That day in Honolulu was a memorable interlude of refreshment between the two acts of our voyage.

Sports and Entertainments.

It is probable that no ship's company ever crossed the Pacific with such varied social, intellectual and æsthetic accompaniment. It must suffice to indicate the nature of this experience, without entering into details.

The music-room of the *Manchuria* contained, besides a library, a fine "Wette-Mignon" instrument, which discoursed classic music as interpreted by famous pianists.

The big boat-deck gave room for several games of "shuffle-board" at once, and this favorite ocean sport was continually in evidence, besides playing its part, through a grand tournament, with appropriate prizes, in the "Carnival."

But the carnival of athletic sports included almost all known varieties—the most unusual of which was a game of baseball, for which the deck was suitably housed with netting. There was also a tug-of-war by the Chinese crew, and a "lion-dance" performed by Chinese on the after lower deck. For the rest, there were egg-and-spoon races, potato-races, needle-threading and cigarette-lighting races, relay-races, children's races, etc. And there was bobbing for apples in water, and biting at swinging apples, and "whistling and guessing," and cock-

fighting and pillow-fighting—the latter repeated on a spar over the big swimming-tank. And there were " the musical chairs "—a synonym for " Going to Jerusalem "—and innumerable other forms of merriment, *extempore* or prearranged. The gayeties of the voyage were crowned with a fancy-dress dinner and dance, and a dinner given by the Pacific Mail S. S. Co. in honor of the A. I. M. E., the latter being characterized by brilliant adornment and illumination, a grand procession of smiling Chinese waiters headed by the bearers of a huge turkey and a little roasted pig, and appropriate toasts to the company and the gallant officers of the ship, who made brief but hearty sailors' speeches in reply.

In the saloon there were frequent addresses by the members of the missionary delegation, upon themes of general interest, such as the learning of the Chinese language, surgical experiences in China, the Chinese anti-opium movement, the present significant features of foreign missionary enterprise, etc.

There were informal sessions of the Institute also, at which papers of interest were read and discussed.

Hawaii, by Charles W. Goodale, Butte, Mont.

The Laramie Tunnel, by David W. Brunton, Denver, Colo.

(Informally discussed by W. L. Saunders, Charles W. Goodale, R. W. Raymond, H. Foster Bain, Robert W. Hunt, and H. S. Drinker.)

Electric Furnace Smelting, by Prof. Joseph W. Richards, So. Bethlehem, Pa.

The Mining Code, by Will L. Clark, Jerome, Ariz.

At one of these sessions Mrs. Sleeper, long a resident of Manila, gave a charming talk about Luzon, illustrated with numerous photographs.

Several sessions were interestingly and profitably occupied by Dr. Reiji Kanda, one of the Japanese Reception Committee, who had been sent to San Francisco to meet our party and escort us to Japan, and who, in colloquial lectures on Japan, its language and its customs, gave us many useful hints and suggestions, preparatory to our sojourn there.

Religious services were held on Sundays, and an amateur double quartette acquitted itself with credit in the singing of the hymns.

The mandolin orchestra of Filipino musicians must not be forgotten. It filled the interstices of other entertainments, and shed upon lunch and dinner a blessing from above.

Finally, there were entertainments on the after lower deck of a kind new in the world—revolutionary Chinese mass-meetings, with orators of singular vivacity, and audiences of singular stolidity. Yet

the orators evidently moved the audiences; for collections amounting to $1,000 in gold were taken in aid of the revolution from the crew, stewards and steerage passengers.

The various features above mentioned were so arranged as not to interfere with each other; and the unbroken smoothness of the sea made it possible to utilize every day, so that there was just time for all (though none to spare), in spite of the fact that a day (Friday, Oct. 27) was lost at the 180th meridian!

On Wednesday, Nov. 1, the following messages were exchanged by wireless:

Hunt: Cordial welcome to the members of the A. I. M. E.
SHIBUSAWA, WADA, OTAGAWA.

Baron Shibusawa: Our members thank you for gracious welcome. We anticipate great pleasure in visiting your country and having opportunity to pay personal respects. HUNT.

And so, merrily, yet not unprofitably, the long voyage glided away, until, at dawn of Friday, Nov. 3, we saw the lustrous snowy cone of Fuji, above the hills of Yokohama.

Yokohama.

We cannot be too grateful for the happy voyage which brought us to Japan full of strength and high spirits; for we needed such a reserve to enable us to endure the strenuous enjoyment of the eighteen crowded days which followed. From the hour when the *Manchuria* passed within the breakwater of the harbor we began imperfectly to realize what kind of reception awaited us. The quarantine examination, facilitated by the unanimous and uproarious good health of the party, was a brief formality; and as for the Custom House, an Imperial order passed all our baggage without examination, so that, bidding it farewell in our cabins on the *Manchuria,* we found it again, unrummaged, in our rooms at the Imperial Hotel at Tokyo that night. But in the interval came a memorable day, the beginning of what was well denominated "a whirlwind tour."

Delegates from the Japanese Reception Committee, the municipality of Yokohama and its Chamber of Commerce, had already boarded the steamship before we disembarked. We were taken ashore in launches, escorted by a fleet of "sampans," and upon landing at the Custom House dock we were received at once into jinrikishas—a novel experience to most of us—and trotted away along the smooth avenue skirting the shore to the stately Grand Hotel, which fronts upon the beautiful harbor. Like all other places visited by our party in Japan, it was decorated with American and Japanese flags. A reception was held by the Yokohama Chamber of

Commerce, at which President Kahe Otani made in the Japanese language the following speech, the English translation of which was read immediately afterwards.

I have the honor to represent the Yokohama Chamber of Commerce today, and in that capacity I deem it my good fortune to be able to express our sincere gratitude in welcoming you here. We welcome you as the representatives of the skill and enterprise which have turned the vast resources of the American continent to the service of mankind. We are largely sharers in these benefits. America is the land of superlatives. You have the biggest of everything. True to your reputation for superlatives, there is an enterprise, the biggest the world has ever seen, which on its completion will revolutionize the lines of commercial traffic all over the

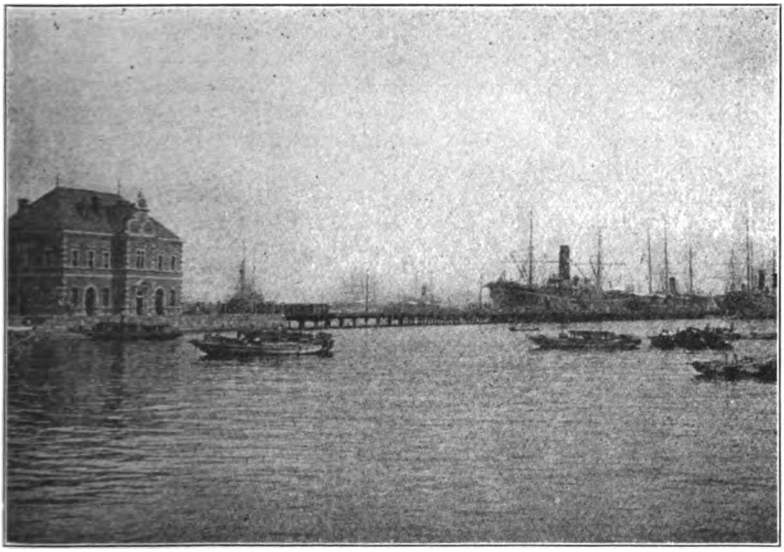


FIG. 3.—THE LANDING AT YOKOHAMA.

world. I allude to the Panama Canal. The Canal, when completed, will cause the commerce of the Pacific ocean to increase a thousand-fold The great Republic from which you came and the country whose guests you are border on the Pacific and will be benefited more than any other countries of the world. Therefore, I think, a commercial understanding is necessary for the two nations, Japan and America, whose interests are identical on the waters of the Pacific. If they unite, it will be the better not only for the two nations but for the world's commerce in the future.

I am sure that your visit to this country will make stronger the tie of friendship that has for so many years bound Japan and America closely together. We will spare no efforts in making your stay with us a pleasant and enjoyable one. In conclusion, I again welcome you as the representatives from the land of superlatives.

Capt. Robert W. Hunt, Past-President, and, by appointment, Acting-President of the Council of the Institute during the Japan Excursion, responded as follows:

President Otani, Ladies and Gentlemen: Speaking as I do for the members of the American Institute of Mining Engineers and their accompanying friends, whom you have so graciously welcomed to your country and city, I beg to thank you most sincerely. We have been looking forward to our visit with bright expectations, but we had not anticipated so prompt and warm a welcome.

You have referred to our country as the land of superlatives, and I fear we are rather apt to boast of it in somewhat such terms, but if you are giving us a sample of the kind of hospitality we are to receive while in Japan, I am certain that in that way at least we will experience larger things than America has ever known. I agree with you that the completion of the Panama Canal will do much for the prosperity of both the United States and Japan; and if it will, as it should, also serve to bind the two nations in closer bonds of friendship, it will accomplish a yet higher result, and one which we in America will value as greatly as you can in Japan.

Again we thank you and the members of your organization for your early and cordial welcome.

At 3 p.m., a reception was given by the city authorities in the handsome new municipal building, which was glorious with banners and chrysanthemums. Mayor Arakawa, at the banquet, welcomed the visitors, saying, in part:

It is my sincere pleasure to welcome the members of the American Institute of Mining Engineers on behalf of the citizens of Yokohama. It is not perhaps required of me to tell you that the relations between America and Japan are the best that we can hope for. The commercial relations between our countries are securely established upon a firm foundation. Japan's export trade during the previous year amounted to 458,000,000 yen, a third of which was sent to America. On the other hand, a greater part of her import trade has been done with America. The fact that these countries can help each other in commerce accounts for exchange visits of representative men of both countries and the consequent enhancement of friendship existing between them. It is our belief that as the men of both countries engaged in commerce come in closer and more direct relations with each other there will be fewer opportunities for misunderstanding or error of any kind in commercial dealing.

Yokohama, being the port which has direct connection with America, may claim special relations with your country. And it is beyond doubt that, upon the completion of the Panama Canal, American-Japanese relations of friendship will be still more improved.

President Hunt replied as follows:

Mr. Mayor, Ladies and Gentlemen: Permit me to thank you, Mr. Mayor, for your kind words of welcome.

We have been in your city but a few hours, but have had time enough to become impressed by its commercial activity and evident good government.

Our party was very anxious to reach Japan in time to unite with your people in the celebration of your Emperor's birthday, and I cannot tell you how many extra tons of coal Captain Dixon, of the *Manchuria*, burned in order to get us here. He succeeded, and thus gave us a most auspicious beginning to our visit, and if this is the way we are to be treated, we regret that our ship did not sail faster.

With all due respect to the personality of most tourist parties, we are not to be classed with them, as we represent an international scientific society, and our members include representative scientific and business men, who are here to make careful inspection of your mining, metallurgical and manufacturing methods. We expect to learn much, and hope we may in return give some suggestions which may be of value.

I am certain that the interchange of such visits must be of value to both countries, and strengthen the existing friendship between them.

We thank the citizens of Yokohama for their hospitality, and wish them and yourself personally all prosperity.

Mr. T. Sammons, the American Consul General at Yokohama, made a brief speech, in which he said that the Americans themselves were largely responsible, through their neglect to make suitable efforts to secure the Japanese trade, for the comparatively small amount of American exports to Japan. He proposed, in conclusion, the health of the citizens of Yokohama, and the Japanese officials, at the instance of the Mayor, responded by drinking the health of their American guests.

The entertainment included a geisha dance, given before the building by thirty brilliantly costumed geisha.

There was time during the day for much 'rikisha riding about the town. This being the birthday of the Emperor, Yokohama was ablaze with flags, lanterns, triumphal arches, etc.; a grand procession was in progress, and the whole population, innumerable children, babies, children carrying babies, and all, was in the streets. In the crowded native and Chinese quarters we saw the city life of Japan at its brightest and best, while the architecture of the public buildings, foreign residences, modern shops and offices, etc., indicated the new era of commerce and progress, of which Yokohama, as the chief port of the Empire, is naturally a foremost exponent.

Tokyo.

The festivities at Yokohama consumed the greater part of the day, and it was after 5 p. m. when the party started by special train for the capital, where they were taken at once to the Imperial Hotel. The city was adorned in honor of the Emperor's birthday, and we

were in time to enjoy one of the most impressive features of the celebration, namely, the annual reception, supper and dance at the residence of the Minister of Foreign Affairs, to which we had received individual invitations—a special honor, since this is a very select affair, attended by the Imperial princes and princesses, the nobility, the diplomatic corps, high military and civil officials, and invited guests. The residence of Viscount Uchida was enlarged for the occasion by roofing the spacious courtyard, so as to create a magnificent suite of rooms, which were decorated with much ingenuity and splendor. The finest of all was the supper-room, the ceiling of which was hung with pendants of wistaria, while at one side a large maple in autumn colors positively illuminated the hall with its

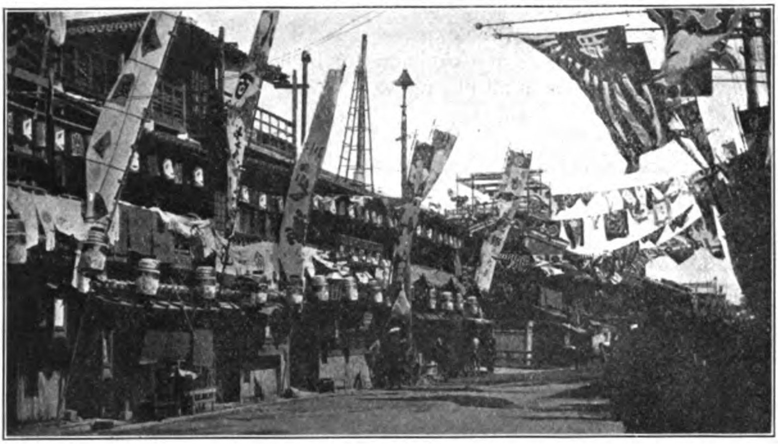


FIG. 4.—CHARACTERISTIC STREET SCENE, SHOWING DECORATIONS.

rosy glow. Wistaria and maple were alike artificial—wonderful examples of an art in which the Japanese excel all others—but the thousands of chrysanthemums were real—and so were the people, among whom we noticed many whose names were famous in war or in peace.

Saturday morning, Nov. 4, the party visited the Imperial University, the Imperial Museum, and other institutions. At the University President Baron Hamao delivered a short address of welcome, to which President Hunt made an appropriate reply. Much interest was taken in the collection of engineering models and of minerals in the Engineering College, of which Prof. Wataru Watanabe, a member of the Institute, is Director.

At luncheon the party was entertained in the noted Seiyoken restaurant, Uyeno Park, by the municipality of Tokyo, Mayor and

Madame Osaki, supported by the three chief officials of the city, receiving the guests.

After toasts in honor of the President and the Emperor, the Mayor made a few remarks, referring to his printed address, which had already been distributed. The address follows:

Ladies and Gentlemen: I thank you most heartily for your goodness in being here to-day. It gives me sincere pleasure to welcome you to this metropolitan city of the Empire of Japan.

Coming, as you do, from a country that is at the van of progress and civilization, I am afraid that the city may have little to offer that may interest you except perhaps in the way of the picturesque and poetical. I scarcely need assure you, however, that whatever there is of interest to you the city is more than willing to place at your disposal. The gates of the city are wide open to you. Our motto is the open door, and you can freely command whatever may help to make your sojourn pleasant and profitable.

You have been here scarcely thirty hours, and yet you cannot have failed to notice that we are in the midst of a transition period. This is in fact the meeting ground of Old and New, East and West. We are emerging out of the exclusive domination of one form of civilization and assimilating whatever is good in another form of civilization. We aspire to be abreast of the most advanced nations of the West in things that are new, while at the same time keeping ourselves in constant touch with our past, of which we naturally feel proud. We do not want to abandon the one in favor of the other; we mean to be loyal to both.

This we can do with perfect consistency, for both the civilization of the East and the civilization of the West are at bottom based on the same ideal of love and peace. If Christ taught you to do unto others as you would have others do unto you, so Confucius taught us not to do unto others as we would not have others do unto us. So you see that the idea is exactly the same, only the forms are different. The same is true of every other case where you notice an apparent difference between East and West. The difference is only in the matter of form; the spirit is the same in both.

Now, Ladies and Gentlemen, if we follow the precept of our respective teachers, how could there be any misunderstanding between us? You see that it is only the idle dream of the poet to suppose that the East must remain East and the West West and the twain may never meet. No, the East will not remain East, neither the West West; they are destined to meet, in fact they are already meeting. Otherwise I could not have had the pleasure of seeing you here to-day.

Of all the agencies that will hasten the process of mutual understanding between East and West, nothing is more potent than a frequent exchange of visits between intelligent men and women on both sides. Nothing helps one so much in understanding another as to meet him face to face; one may not understand the other's language, but one can hardly fail to understand the other's heart. In this sense I attach particular value to visits of men and women like you—men and women who belong to that class which molds public opinion and fashions the destiny of the com-

munity. The city of Tokyo welcomes you as messengers of peace and good understanding between the leading nations on both sides of the Pacific.

Ladies and Gentlemen, I ask you to drink the health of our honored guests.

President Hunt replied as follows:

Mr. Mayor, Your Excellencies, Ladies and Gentlemen: I know I am voicing the feelings of all the members of the American Institute of Mining Engineers' party when I express the fullest appreciation of your honor's most gracious and eloquent words of welcome to the capital city of your country. It is true that we have been in Japan but a few hours, but they have been very busy ones, and we would be both blind and dull if we had not been impressed by the many evidences of material progress which we have already seen, and also callous in feeling if insensible to the warmth of the welcomes extended to us.

We are looking forward with much interest to our coming visits to many of your historic and classical places, but with equal desire to our examinations of some of your more prominent mining and industrial centers. If we had doubted Japan's modern achievement, your own city's development would have dispelled that feeling. As its Chief Official, you, sir, certainly have full right to be proud.

I fully agree with you that personal intercourse is the best way for people to understand each other, and if our visit shall in any way tend to bring our respective peoples in accord, that result will be far more valuable than any personal pleasure or other advantage which we may derive from it.

With a people actuated by such broad and noble sentiments as you have so beautifully expressed there can be only a bright and glorious future; and let us hope that your country and our own may always be united in the endeavor to establish them as the guiding policies of all nations.

We highly value your welcome and hospitality, and most heartily thank you.

Mayor Ozaki then introduced Baron Uchida, who said:

In greeting the members of the American Institute of Mining Engineers, I must confess at the outset that I am a layman in mining industry. But during my recent stay in Washington as a diplomatic representative it was a very great pleasure for me frequently to visit different States. Almost without exception, in every State I had the good fortune to go to, I was most profoundly impressed by the astonishing development of your commerce and industry. In no other country in the world have I ever seen such marvelous display of human energy for the furtherance of commercial, economic and industrial enterprises. There all the best qualities in men seem to be fully employed in these spheres of human activities. The dominant American characteristics, therefore, unmistakably point to the fact that America was one of the foremost among the nations of the world to recognize the dignity and glory of commerce and industry, which naturally links and unites different peoples to their mutual benefit and

advantage, and which thus, as on the present happy occasion, serves to promote the cause of peace and good-will among them.

I understand that the purpose of your visit to this country at this time is neither of a technical nor a business nature. Your principal object is rather social, and it is our earnest hope and expectation that our closer contact and more intimate intercourse will greatly increase and broaden that knowledge of each other which is, after all, the sure foundation of real friendship. It is therefore with peculiar pleasure that I welcome you here this afternoon; and in this meeting I trust that we are forging one more link in that chain of cordial friendship which already so happily binds together the peoples of the great Republic in the West and the Island Empire of the East. While thus welcoming you I want particularly to assure you that there is nobody in this country, I am sure, who will not in every way possible be glad to contribute to the pleasure of your sojourn among us. It is, therefore, our sincere wish that you shall have every opportunity to see this country fairly; and, in saying this, I would express the hope that your stay in Japan may be as agreeable to you as your coming is welcome to us, and that you may take back with you happy memories of a happy trip. I feel sure that all of you are with me when I say that the courtesies which we are extending to the guests here to-day are but modest, though sincere, expressions of the very high esteem which we in common entertain towards them and their countrymen.

At the request of President Hunt, Dr. Raymond, Secretary Emeritus, responded, in part, as follows:

In the hands of the mining engineers of Japan, not less than in those of its wise statesmen and brave soldiers, lies the future of the Empire. The Japanese themselves cannot so fully appreciate as do those of other countries the achievements of their own engineers, especially in the wonderful development of the mining and metallurgical industries of Japan.

Their American brethren, who have been glad to give them suggestions, have found them quick to learn, and even to improve by their own ingenuity the knowledge they had thus gained.

The members of the American Institute of Mining Engineers would learn many things from their Japanese colleagues—above all, the lesson of hearty co-operation and fraternal unanimity. The power of such unanimity could have no higher illustration than it received in the late war with Russia, which exhibited an army perfect in loyal enthusiasm, from the private soldiers to the highest commander. Men so unanimous in dying, would be omnipotent if they lived!

In the afternoon visits were made to Asakusa (which has been called the Coney Island of Tokyo, though it is not on the seashore) and to the Wrestling Hall, occupied at this time by a grand chrysanthemum show. Here the party was welcomed with excellent music by the band of the Imperial Body Guard.

In the evening a dinner was given at the Imperial Hotel by the Japanese Reception Committee. The great banquet hall was splen-

didly and tastefully decorated with flags and flowers. Baron Shibusawa, Chairman of the Japanese Reception Committee, presided and made the opening address of welcome, and, at his request, Viscount Kaneko subsequently assumed the duties of Toastmaster, and admirable speeches were made by Count Okuma, Baron Makino and the Toastmaster himself, of which, unfortunately, no reports have been preserved. The responses for the Institute were as follows:

PRESIDENT HUNT.

Your Excellencies, Mr. Toastmaster, Ladies and Gentlemen: After such eloquent words of welcome to the members of the American Institute of Mining Engineers and their accompanying friends who are your guests to-night, and particularly after the complimentary personal introduction, I hesitate in performing my pleasant duty of returning thanks for them.

Viscount Kaneko: You have referred to my personal connection with the introduction into America of the Bessemer process of making steel. It is quite true that it was my fortune to be one of the first Americans to be connected with that industry.

It is hard for any one who has only known of Bessemer steel since it became so important a factor in the world's affairs to realize that there was ever any doubt of the practicability of its manufacture, and the value of the metal. But such was the case, and many difficulties had to be overcome, and we who were connected with its early days had far from easy times.

As has so often happened in the world's history, its invention was made at a time when such a material was absolutely required. The increase of the weight of railway locomotives and cars and the speed of trains, all of which had become necessary to handle the increased and increasing business, had demonstrated that rails made of iron, no matter how manufactured, were not equal to the requirements. In fact, they were breaking, crushing and otherwise wearing out to such an extent that without some great improvement, further railway progress was impossible. Bessemer steel solved the problem, and also led to many other engineering accomplishments.

Naturally, it is a personal satisfaction to have been of some use in bringing about such a metallurgic and economic development, and I thank you, sir, for your reference to it.

Speech is easy, but no matter how eloquent and complimentary may be the utterances, there cannot be the same value attached to them as though they told of acts already performed as well as promising others to come. We have been in Japan less than two days, but have already been given such striking examples of heartfelt welcome and hospitality that to-night, no matter how eloquent your words may be, they have already been exceeded by acts.

Yesterday we landed in one of your seaports and enjoyed the freedom of that busy, prosperous and progressive city. Last night we had the privilege of joining in the celebration of your Emperor's birthday. To-

day we have been shown through your Imperial University and have had explained to us the broad and comprehensive lines of its curriculum and equipment. Later we visited your National Museum and Art Gallery, followed by a reception and lunch given us by the Mayor of Tokyo, where we were welcomed to this city in words eloquent and sympathetic by his Honor; he was followed by his Excellency, the Minister of Foreign Affairs, who also most graciously and hospitably welcomed us to Japan, and while so doing gave great praise to the enterprise and energy of our own countrymen; and now to-night we are being entertained by the Reception Committee, and again assured of the pleasure felt in having us as guests in Japan.

We certainly have every reason to believe you want us with you. We of America think and sometimes venture to claim that we are energetic and do things, but judging from the record I have just recited, I am prepared to bow to our friends of Japan.

Why should not the two countries be friends? There together hang the two flags. Perhaps only those of us who have followed our flag through the smoke, roar and carnage of battle can fully realize what it symbolizes. Both flags have been consecrated by patriotic blood; both have been sanctified by the patient suffering of mothers, sisters and orphans; both stand for the enlightenment, progress and uplifting of humanity. May they ever hang together, typical of the friendship of the two nations.

Dr. R. W. Raymond.

I thank you heartily for the terms in which you have called upon me. It is true that for forty years—since the organization of the Institute in 1871—I have been more or less connected with its management, first as President for four years, afterwards during two terms as Vice-President, then for nearly twenty-eight years as Secretary. During that period it has been my privilege as the official representative of the Society, with the cordial support of its members, to illustrate the great principle of modern progress—namely, the free interchange of knowledge. There is a good deal of controversy about free trade in commodities; but knowledge is a commodity on which there should be no tariff; and the communication of which enriches both him who receives and him who gives. In science he who discovers a new fact or a new law makes haste to let it be known, and every profession or trade becomes scientific in proportion as it is imbued with that spirit. In mining or metallurgy, he who jealously hoards and hides his own knowledge will find that it withers or decays in his hands. We engineers have found that when we light another man's candle from our own, we ourselves have twice as much light as before. And of all the instances of this friendly interchange, none has been more interesting and delightful to me than the international courtesy and assistance which I have been able to extend to the engineers of Japan visiting the United States, and which they and their countrymen this day so gracefully acknowledge and so royally return. I read from the good ship *Manchuria* one day last week an object lesson in the sky. It was just dawn. The stars hung splendid in the heavens, looking down upon the great Pacific sea with a brightness unknown, methinks,

elsewhere. The whole firmament was the escutcheon of my country's flag —and I repeated to myself the words of our American poet:

"When Freedom from her mountain height
Unfurled her standard to the air,
She tore the azure robe of night
And set the stars of glory there!"

But presently the dawn deepened to-day. Lo! the new banner of the Rising Sun! and I saw the two flags twined in friendship, for the stars have no quarrel with the sun—each star itself a sun—but gladly blend their rays with his, to gild the world for a new day!

But I saw something else—a bright comet streaming towards the sunrise, like a messenger of greeting from the stars. My friends, if I were a poet, I might regard that comet as fitting symbol of this our embassy of peace and friendship. I might describe its glowing nucleus—our strong men; and its flowing adornment—our fair women. But one consideration should forbid such a comparison, even to a poet, namely, it is too long, too awfully long, before a comet comes again!

PROF. JOSEPH W. RICHARDS.

Prof. Joseph W. Richards, Vice-President of the Institute, expressed the satisfaction felt at meeting personally so many professional friends heretofore known only by name, and the privilege it was to make so many new friends among our Japanese colleagues. He agreed thoroughly with the patriotic sentiments called forth by the national hymns, but hoped that such spontaneous and natural patriotism for the country of one's birth would lead up to a world patriotism, a passion for humanity, which would equally command devotion and inspire sacrifice for the greatest good of mankind. Over and above the Star Spangled Banner and the flag of the Rising Sun might we not place the emblem of the "Federation of the World," the token of universal brotherhood and the pledge of permanent international peace?

A pleasant feature of the banquet was the appearance of two handsome albums, in which all who were present signed their names. One of these albums was given as a souvenir to the Institute and the other was retained by the Reception Committee.

Sunday, Nov. 5, the party visited the Military Museum at Kudan, and the Imperial Garden at Shinjuku, being subsequently entertained at luncheon by the Mining Institute of Japan in the celebrated Maple Club, where the guests partook of Japanese dishes with the aid of chopsticks. Prof. Wataru Watanabe, President of the Mining Institute of Japan, delivered the following address:

Ladies and Gentlemen: On behalf of the Mining Institute of Japan I have great pleasure in offering you, the visiting members of the American Institute of Mining Engineers, their families and friends, a most hearty

and cordial welcome to our country. I want also to express our warmest thanks to you for your kind presence at this luncheon.

The entertainment which it is in our power to offer you to-day is hardly adequate to embody the warm feeling with which we welcome you; it may, I am afraid, appear especially poor to those accustomed to the opulence and magnificence of social functions in your great country. It is, however, purely in Japanese styie, and it may on that account be of some interest to you.

Ever since the opening of our country to the outer world we have been honored by visits of various distinguished personalities from abroad, but this is the first time in the long history of our country that we have had the honor of receiving and entertaining such distinguished representatives of an important scientific institution. We, therefore, are very proud of this virginal honor, and venture to hope that your visit may induce other institutes and societies to follow your example, and help in making America and Japan—teacher and pupil—understand each other more thoroughly.

I have been asked to give you a very brief outline of the history and the present condition of our Mining Institute, and of our mining industry in general.

Our institute was founded in February, 1885, for the express purpose of promoting the interests of our mining industry at large, for which purpose general meetings are held annually in Tokyo, and extraordinary meetings now and then in Osaka and other towns. In every case technical papers are read and discussed. A monthly journal is also published from the institute, and it attained its three hundred and twentieth number last month. The membership numbers 1,144 at present, and includes almost all the mine-owners and mining engineers of this country. Of course, owing to their profession, most of them live at the various mines in different parts of the country, which accounts for their comparatively small attendance to-day in this hall. Still, some of them have come from afar expressly to have the pleasure of being among the hosts of the distinguished and representative guests who honor us to-day with their presence.

Now let me show you how much we owe to the people of the United States in attaining to the present state of our mining industry.

It was two of the members of your institute, Prof. William P. Blake and Prof. Raphael Pumpelly, who made scientific investigations of the mineral resources of the then still-wild Yesso Island (now called Hokkaido) in 1862, the first of the kind ever attempted in our country.

It was also these two gentlemen who first taught us the art of blasting at the Yurap lead-mine on that island in September of the same year, thus initiating the introduction of the modern method of mining into this country.

It was likewise one of your fellow-members, Mr. Benjamin Smith Lyman, who first conducted the geological survey of the Yesso Island from 1872 to 1879, the embryo of the present Geological Survey of Japan.

It was again from your country that we first learnt the art of rope-boring for oil, the pan-amalgamation process for silver and gold, and the Bessemerizing of copper-matte, which have contributed so much to increase the output of these mineral products in this country.

Fig. 5.—Luncheon with the Mining Institute of Japan at the Maple Club, Tokyo.

It was direct from your country that we first introduced such purely American mining-machinery as Californian stamps, rock-crushers, Huntington mills, Frue vanners, Wilfley tables, Ding's magnetic separator, water-jacketed copper blast-furnaces, etc.

Great as is the benefit received from you in material things, greater still is the benefit we have from America, along with the countries of Europe, in the way of education relating to mining and metallurgy. In this way was laid the foundation upon which the present edifice of Japanese mining industry, with a yearly production exceeding in value 100,000,000 yen, has been built. More than one-half of this is coal and about one-quarter copper. Our mining industry is a mere baby, it is true, in comparison with your giant industry, having an annual production of about 3,000,000,000 yen. Still, we are proud to be able to say that we have more than doubled our mineral production within the last decade, and hope, with your further kind assistance, to retain, if not to exceed, the same rate of increase in the future.

We regret very much not to be able to show you, owing to lack of time, any of the numerous mines working a very unique kind of ore-deposit, quite unknown in your country, and perhaps in the whole world, with the single exception of the so-called *Grauers* of Rammelsberg in the Lower Harz, Germany. I mean that of *Kuromono,* literally meaning "Black-Ore," the largest and best known example of which is to be found at the celebrated Kosaka mine in the Province of Rikuchu. The ore itself is an intimate mixture of heavy spar, zinc-blende, iron and copper pyrites and galena, assaying not more than 2 per cent. of copper and two-thirds of an ounce of silver per ton of ore, defies every known method of mechanical concentration, and is only fit for reduction by the genuine pyrite-smelting process.

This peculiar kind of ore-deposit is found at a great many localities in the northeastern part of Japan, and is considered as a metasomatic deposit replacing the contact-zone between Tertiary eruptive and sedimentary rocks. Regarding its genesis, it may be worth while in this connection to mention that there is in that district a hot spring which deposits on its surface ground a crystallized sinter composed of the sulphates of lead and barium, a radio-active mineral hitherto unknown in the world. The same kind of hot spring was also discovered in the island of Formosa in 1906. Future scientific investigation on these hot springs and sinters may throw some light on the solution of problems regarding the mineral deposition of complex sulphide ores in general.

I am not going to tax your patience any more now, but will content myself with saying that, as it is impossible to show you even a mere fraction of our mining industry during your very short stay this time, we may be allowed to express our sincere wish and hope to have you amongst us again in the near future with more time at your disposal.

Now I request the members of the Mining Institute of Japan to join me in drinking the health and happiness of the visiting members of the American Institute of Mining Engineers, their families and friends. [A treble Banzai!]

President Hunt responded as follows:

President Watanabe and Gentlemen of the Mining Institute of Japan: On behalf of our party of the American Institute of Mining Engineers

FIG. 6.—THE ORDER OF THE RISING SUN (FOURTH CLASS).

The badge is a star of red enamel, with rays of white and gold, above which are the private arms of the Emperor's family—the green leaves and lilac flowers of the *Paulownia*. The ribbon is white, with scarlet edges, and bears, for this class, a chrysanthemum rosette in red and white, which indicates the rank of an officer in the order. There are eight classes: the first comprising the Emperor only, and the second and third personages of royal or otherwise exalted rank or exceptional merit. The fourth class, which is regarded as a high distinction, is sometimes bestowed upon foreigners.

and their accompanying friends, I thank you not only for your cordial words of welcome, but also for the, to us, unique and most delightful entertainment which you are giving us. It most certainly is a great treat to us and we are fully enjoying it.

Yesterday we reverenced you, sir, as the head of a great mining school; to-day we respect and admire you as a most hospitable and genial host.

In your gracious words of welcome you have spoken of the natural resources of America, and the many great accomplishments of its engineers and business men, and with all due modesty, we will accept them as being true. But why should it have been otherwise with us? If our people had failed to utilize their opportunities and made use of their great natural wealth, they would have proved unworthy of their heritage. It is those who are surrounded by limited resources and other untoward conditions, but yet accomplish things, to whom the greatest praise is due. So we of America regard our friends and fellow-engineers of Japan, and bid them "All hail." You have also given American engineers credit and praise for their assistance to those of Japan. As an educator, you have experienced the pleasure derived from imparting knowledge to intelligent and apt students. And so if American engineers have taught anything to yours, they have already had full evidence of the intelligence of their pupils.

As yet we have not had time to see much of your country, and to visit personally any of your mines and other industries, but we know from our reading and from that which we have already seen of your modern progress, what we may expect to find, and so again say "All hail!"

Again we thank you and your associates for your hospitality and the great pleasure you are giving us.

Later in the day a social reunion was given at the Mitsui Club by Baron Makino, Minister of Agriculture and Commerce. A novel entertainment was here furnished by a company of skilled potters, who made cups, vases, etc., permitting each guest to paint his own inscription upon the article, which was then baked before his eyes and presented to him.

On this day the announcement was publicly made that the Emperor had been pleased to confer upon Dr. George F. Kunz, of New York City, for his scientific work on jade and precious stones, and upon Dr. R. W. Raymond, Secretary Emeritus of the Institute, in recognition of his services to the mining industry of Japan, especially through courtesies extended in America to Japanese students and visiting engineers, the decoration of the Order of the Rising Sun (fourth class).

Kyoto.

At 10.50 p. m. Nov. 5, the party left the Shimbashi station, in Tokyo, by special train for Kyoto, arriving at 2 p. m. the next day. The sleeping-cars were new and most comfortable; the cuisine of the dining-car was excellent, and the polite attention of the railroad servants was beyond criticism. The Japanese railways are narrow-

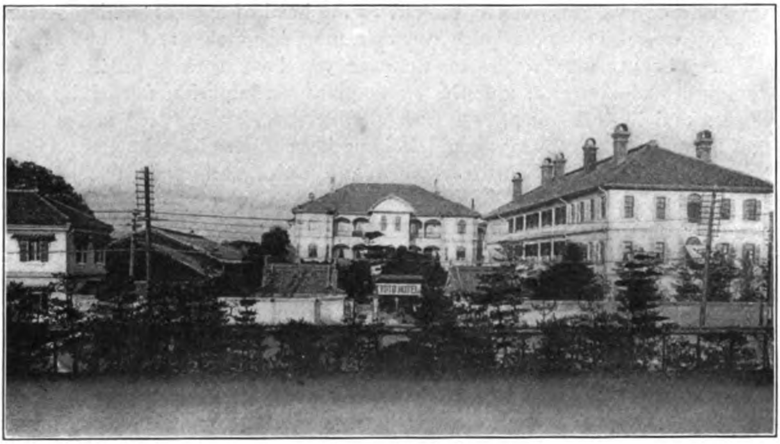


FIG. 7.—THE KYOTO HOTEL.

gauge (3 ft. 6 in.), but exceedingly pleasant to travel on, the road-bed being generally good, the lines free from violent curves, and the speed never very high.

An observation-car was attached to the train, from which glimpses could be had of the highly cultivated, garden-like country. Unfortunately the morning was misty, and Kyoto was reached in a regular rain; but the travelers, welcomed at the station by Baron Kikuchi, President of the Kyoto Imperial University, Mr. Moriko Ohne, Mayor of Kyoto, and other leading officials and business men, were

FIG. 8.—THE GOLDEN PAVILION, KYOTO.

FIG. 9.—ASSAY-LABORATORY OF THE MINING AND METALLURGICAL INSTITUTE, KYOTO IMPERIAL UNIVERSITY.

speedily tucked into jinrikishas, provided with tops and waterproof coverings, and thus brought unharmed to their respective hotels, the Miyako and the Kyoto. During the afternoon nearly everybody went shopping, protected by big Japanese umbrellas. At seven the rain—the only rain that even tried to interfere with the Institute programme in Japan—ceased, and a clear moonlit evening followed. Characteristic native dances were performed at the hotels.

Tuesday, Nov. 7, the party visited the Old Imperial Palace, the

FIG. 10.—MUSEUM OF THE MINING AND METALLURGICAL INSTITUTE, KYOTO IMPERIAL UNIVERSITY.

"Gosho," formerly the residence of the Mikados; then Nijo Palace, built by Iyeyasu in 1603, where the gorgeous decorations of some of the greatest artists of Japan were viewed and admired; a brief inspection of the Temple Kitano-no-Tenjin and the Kinkakuji, or "Golden Pavilion," closed the morning trip.

A reception was held in the afternoon at the Imperial University of Kyoto, where an address of welcome was made by Baron Kikuchi, the president, to which President Hunt responded:

President Baron Kikuchi and Gentlemen of the Faculty: Permit me to thank you, Baron, for your words of welcome, and also for the opportunity which you have given our party of the American Institute of Mining Engineers and their accompanying friends to visit your University and see your Mining, Mechanical and Electrical Engineering departments, and also partake of your hospitality, not only in the way of bodily food, but also in receiving so unique and artistic presents.

FIG. 11.—STUDENTS' UNION, KYOTO IMPERIAL UNIVERSITY.

We have been much impressed by that which we have seen, and I think particularly by the fact that you have spent your money, not on buildings, but on the working equipment which they contain. As engineers, we appreciate the wisdom of so doing, and I fear that some of our institutions of learning have not been equally wise.

We have with us to-day as one of our party Dr. Henry S. Drinker, President of Lehigh University, and Prof. Joseph W. Richards, of the same University, the latter also being a Vice-President of the American Institute of Mining Engineers, and I feel certain you will be pleased to have some words from them.

I take pleasure in introducing President Drinker.

President H. S. Drinker made an appropriate address, expressing the fellowship of institutions of learning.

Prof. Joseph W. Richards, Vice-President of the Institute, expressed the particular gratification felt at meeting their colleagues of Kyoto University. It made him feel very much at home. On visiting Moscow, after being at St. Petersburg, he felt "This is really Russia"; similarly, coming to Kyoto from Tokyo, he could not but exclaim "This is really Japan."

The visit to the University was very instructive, particularly because under an unpretentious exterior, in plain but roomy buildings, were to be found a teaching staff and equipment of which any university might be proud. The practice of multiplying costly buildings, partly filled with second-class teachers and third-class equipment, was only too common abroad, and yet was absolutely inimical to true university prosperity.

With such faculty and facilities, the speaker would recommend all Japanese students to finish at home their undergraduate education, taking

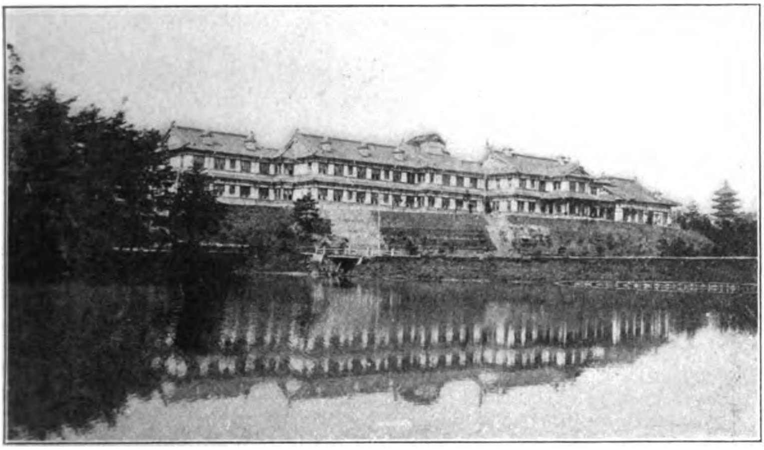


FIG. 12.—THE NARA HOTEL.

from their own universities all they had to teach, and particularly to prepare well in the English, German and French languages. Thus prepared, foreign universities will be very glad to welcome them to whatever they have to give of further training or higher inspiration.

Expert Japanese artists executed rapid sketches before the party, giving one to each guest as a souvenir.

In the evening a reception and banquet was given by the Municipality and the Chamber of Commerce. The dinner was preceded by a solemn performance of the ancient Japanese "tea-ceremony." The rooms, decorated with examples of the skill and taste of native "flower-artists," were much admired.

Mr. Moriko Ohne, the Mayor of Kyoto, delivered an address of welcome, to which President Hunt responded as follows:

Mr. Mayor: Permit me as Acting-President of the American Institute of Mining Engineers to thank you for your most gracious words of welcome.

We have spent a delightful day in your old and classic city. We have visited your ancient palaces and temples, and, standing in them, have tried to recall the history and scenes of past centuries, with the hopes, aspirations, accomplishments and failures, of the actors therein. As we did so how brief seemed the span of man's life, and how puny his greatest deeds! But the temples ever speak of all men's universal recognition of a great creative power beyond their most profound comprehension.

Later in the day we visited Kyoto University, and there saw one of modern Japan's arsenals of thought, where are made ready warriors of peace, who shall help to keep your country in her present high place among the progressive nations of the earth.

Your people honor us with their friendship, and we can assure you

FIG. 13.—FIRST TORII AT KASUGA SHRINE, NARA.

that America appreciates it, and joins you in the earnest hope, and also belief, that it shall continue always.

The speechmaking was followed by admirable geisha-dancing.

Nara.

Wednesday, Nov. 8, an early special train conveyed the party to Nara, the capital of Japan in the eighth century, and the center, at that period, of the new architecture which came, with Buddhism, from China. Here the historic Shinto shrine, Kasuga-no-Miya, was visited, and the interesting old religious dance known as "Kagura" was performed by young priestesses. The Todaiji temple, with the

neighboring great bronze Buddha, also received attention. This statue is the largest of its kind in the world (53 ft. 6 in. high; length of finger, 4 ft. 3¼ in.; diameter of nostril, 3 ft.; circumference of the lotus-flower, 69 ft., etc.), though the bronze Buddha at Kamakura is deemed finer as a work of art. Other temples were visited also. But perhaps the most fascinating experience of the day was had in the temple-gardens, behind and around the temple first named above, which is surrounded by tall old cryptomeria (the stateliest and most impressive of evergreens), in the shade of which roam the tamest little Japanese deer, eager to eat from the hands of visitors. The strange

FIG. 14.—ENTRANCE TO KASUGA SHRINE, NARA.

FIG. 15.—THE DAIBUTSU AT NARA.

charm of this sylvan scene is enhanced by the circumstance that the temple is approached through an avenue bordered by about 3,000 metal or stone lantern-posts.

The deer were in evidence again when, after an excellent lunch at the Nara Hotel and a visit to the Commercial Museum, a reception given by the municipality was preceded by a lawn-party of a large herd of deer, which set the travelers a model example by showing how frequently they could be fed without loss of appetite. For after the deer, the human company had to be nourished again!

In connection with this banquet, the Mayor of Nara welcomed the party, and President Hunt responded as follows:

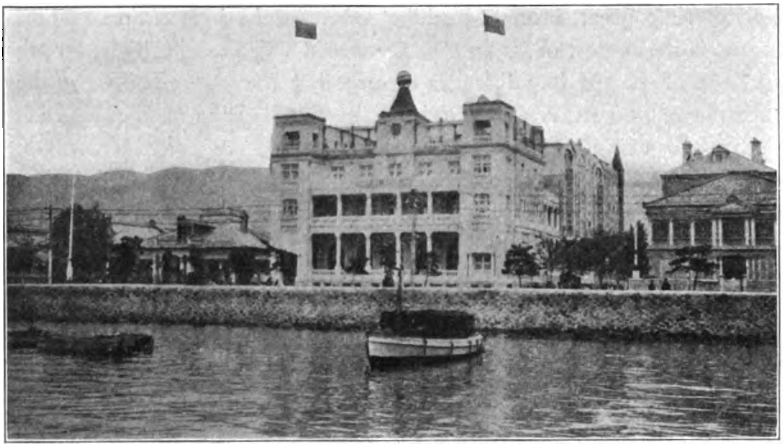


FIG. 16.—THE ORIENTAL HOTEL, KOBE.

Mr. Mayor: I know I voice the sentiments of all the members of our party in thanking you for this official and most hospitable welcome to your historic city. Undoubtedly many tourists visit Nara, but I think it justice to you and ourselves if I explain that we differ from most of them by being the accepted representatives of an international technical organization with more than four thousand members, and about forty of them honored citizens of Japan. Thus we feel as though those of us from other countries can claim a keener appreciation of the associations connected with the history of your city than most foreigners.

Most of us now visit it for the first time, and have been fairly overwhelmed by the beauty and grandeur of its setting. We have visited

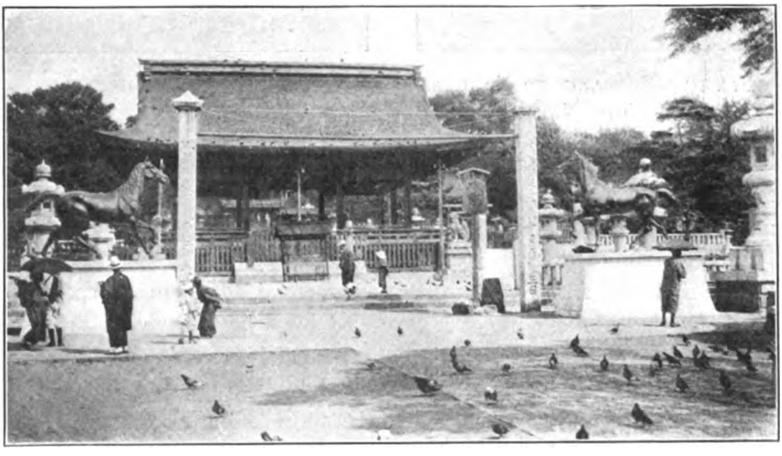


FIG. 17.—THE NANKO TEMPLE, KOBE.

its temples and were subdued by awe; our minds being carried back to the time of the builders; and standing amid their majesty we reverently felt the spirit of adoration which caused their erection and dedication to the Great Power, and had borne in upon us, that differ as men may in their definition of that Power, all humanity recognizes it, and realizes man's littleness before it.

If our visit to Japan had shown us Nara alone, the journey would have been well taken. We thank you for adding the gracious hospitality of the city.

Kobe.

At 4.25 p. m. the party resumed its train and reached Kobe, after

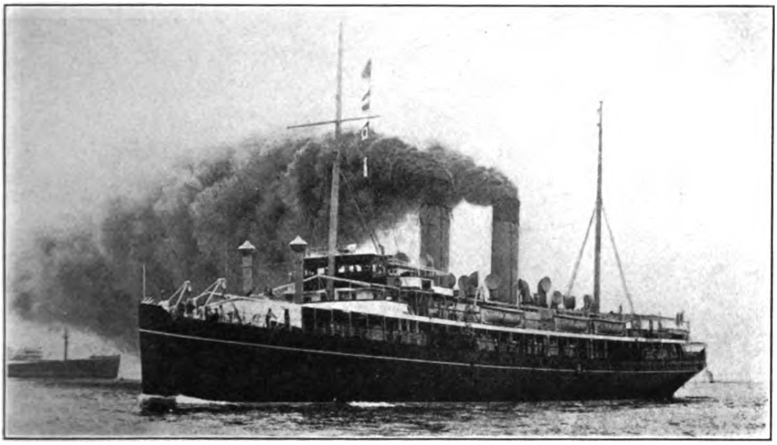


Fig. 18.—S. S. *Umegaka-Maru.*

a journey through very picturesque country, at 7. Here they were conveyed to the Oriental Hotel for dinner; and after dinner they boarded the *Umegaka-Maru,* the large steamer of the government Railway Board, which was to carry them through the Inland Sea, and which lay in the harbor, brilliantly outlined with electric lights, alow and aloft, and bearing amidships in glowing letters the word "Welcome." There was no time to do any sightseeing in Kobe; but the transit through the town gave a distinct impression of its modern aspect. It is indeed a great international port, second in that respect to Yokohama only.

Shisaka and Sumitomo.

The *Umegaka-Maru* afforded, throughout this memorable voyage, excellent accommodation and a cuisine which tempted as well as satisfied the much-nourished company. Kobe was left at midnight, and the first stop was made at Shisaka Island in the forenoon of the fol-

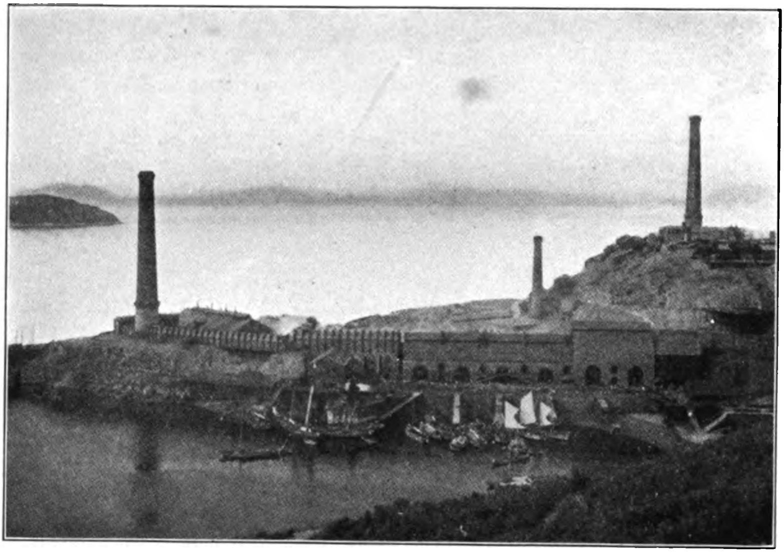


FIG. 19.—SUMITOMO SMELTING-WORKS OF THE BESSHI COPPER-MINE AT SHISAKA ISLAND.

lowing day, Thursday, Nov. 9. As the anchor was dropped, volleys of fireworks saluted the guests, and from bombs exploding hundreds of feet above them American and Japanese flags were unfurled, to float over their heads. After landing in barges the party proceeded through a huge arch of welcome, and up the main street between

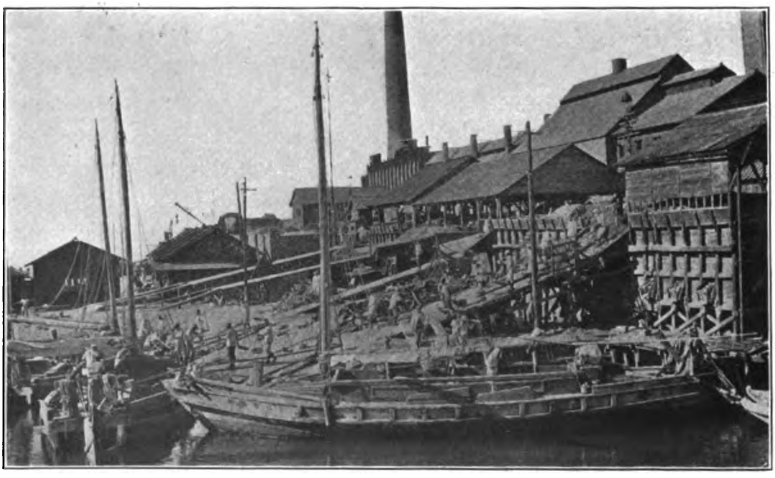


FIG. 20.—UNLOADING ORE AT SUMITOMO SMELTING-WORKS.

[34]

lines of cheering women and children. The ladies were then taken to visit the temples and schools, while the men inspected the Sumitomo smelting-works.

The two parties subsequently united at the works, where they were welcomed by General Manager Munio Kubo, to whose address President Hunt replied:

Permit me, on behalf of the visiting members of the American Institute of Mining Engineers and their accompanying friends, to thank you and

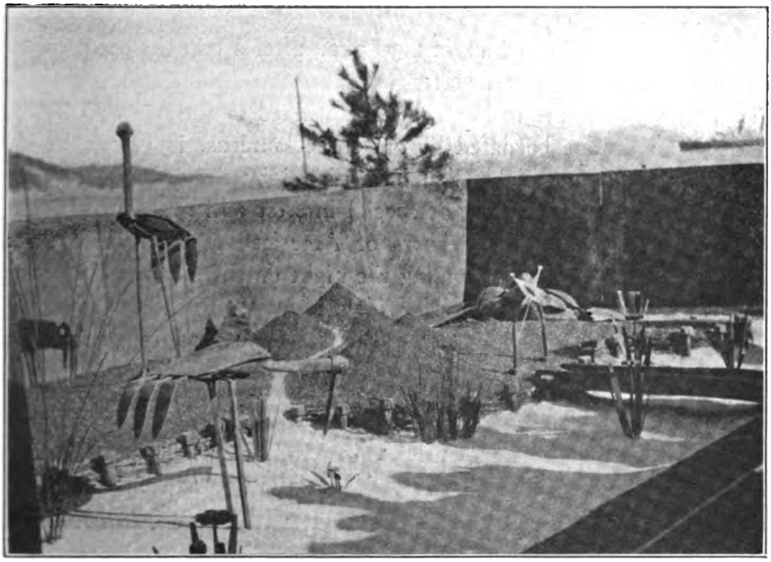


FIG. 21.—UNIQUE DISPLAY BUILT OF DISCARDED TOOLS, ETC., BY WORKMEN, SUMITOMO SMELTING-WORKS.

the Sumitomo Copper Co. for your cordial welcome and the opportunity of inspecting your smelter.

We awakened this morning amid the magnificent and picturesque scenery of Japan's justly world-wide famed Inland Sea, and later we saw the evidences of man's indomitable progress looming against the sky-line of your own island. Soon followed the welcoming sound of your saluting bombs, resulting in the floating through the air of the united flags of our two countries. You later brought us ashore to be greeted, not only by your whole happy-looking community, but also by official representatives of the Governor of this Prefecture, which latter courtesy I assure you we duly appreciate.

Yours is the first Japanese metallurgical establishment visited by us, and it seems superfluous for me to tell you, who so well know the fact, of its excellence and modern equipment.

As you are aware, we have of our party several gentlemen who are thoroughly posted on copper-smelting, so to-day you have appreciative guests.

We request you to inform your artistic workmen that all of us greatly admired the ingenious designs which they constructed to add to our welcome.

Again, we thank you, and wish your company, and yourself personally, all success.

The voyage was resumed amid renewed cheers and farewell fireworks.

Miyajima.

Miyajima was reached about 6.30 p.m., after a trip the picturesque beauty of which will never be forgotten. After dinner on board ship, the party went ashore in launches, and walked to the Mikado Hotel through an avenue bordered by old stone lanterns, in which, as an extraordinary honor, lights had been placed by the priests. At the hotel a geisha entertainment of special interest and grace was given, in which the use by the dancers of American and Japanese flags formed a feature. After spending the night on the steamer the party landed again on the morning of Friday, Nov. 10, to see the sights of this exquisitely lovely and sacred island. The Kagura dance was given for them at the Itsukushima shrine.

Moji and Yawata.

Friday evening the steamer left for Moji, where it arrived next morning, Saturday, Nov. 11, and was met by a fleet of steam-launches

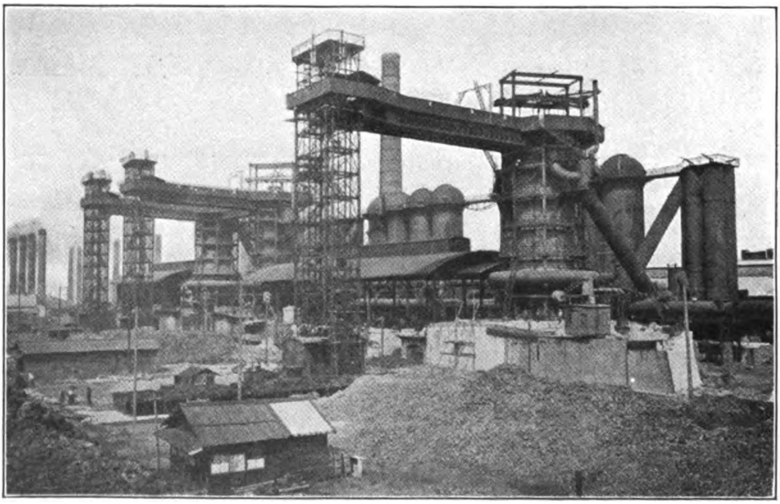


FIG. 22.—THE IMPERIAL STEEL-WORKS, YAWATA.

and tugs gaily bedecked with flowers and bunting, while fireworks on shore expressed a festive welcome. Mr. Takichi Aso, President of the Chiku-ho Coal Mining Association, accompanied by other leading citizens, welcomed the party, and the steamer was immediately taken to the Imperial Steel-Works at Yawata. The men inspected the works on a special works train, while the ladies were served with refreshments at the club attached to the establishment. At noon the party

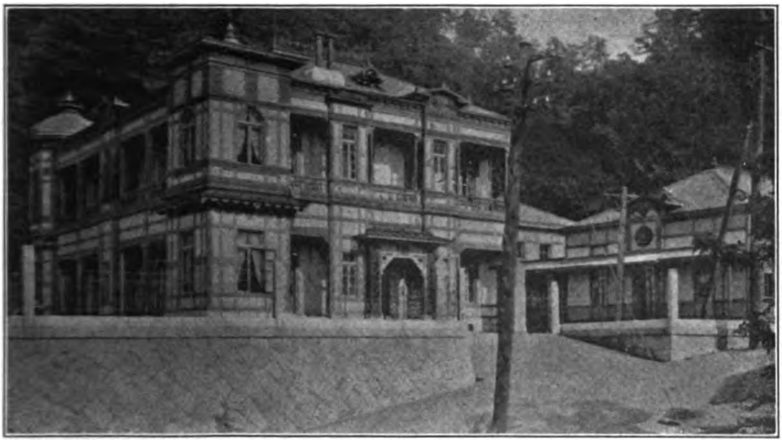


Fig. 23.—The Moji Club.

returned to the boat which had conveyed them from Moji, and Mr. Asakichi Yasukochi, the Assistant Director of the works, delivered an address of welcome, to which President Hunt replied as follows:

Speaking for the members of our party who had the privilege of inspecting your works, and partaking of your hospitality ashore, and now again aboard of our ship, I want to thank you.

As practically all of my business life has been connected with iron- and steel-making, I personally had great interest in the visit, and take the liberty of expressing to you my appreciation of the very superior manner in which the steel was rolling. At the blooming, rail, wire, structural and merchant mills the steel was everywhere showing a superior quality, of which your management have a right to feel proud.

As you well know, your various departments are of less capacity than many in our American plants, but I have no doubt when considered in relation to the requirements of your markets, they are large enough. At all events, in every one of them we saw neatness and evidence of careful management.

With you we regret that official duties prevented your President, Lieutenant-General Baron Yujro Nakamura, meeting us, and you will please present our respects to him.

We thank you and your assistants for your hospitality and courtesy, and wish you and your works all success.

In the evening a gala dinner was given in our honor by the Chiku-ho Coal Mining Association. President Takichi Aso delivered the following address of welcome:

Ladies and Gentlemen: As President of the Chiku-ho Coal Mining Association, I thank you sincerely for your kind presence here to-day. We are highly gratified by your extending your visit to this part of the country. I am sure you will not regret it, for we may assure you without offending our sense of modesty, that North Kyushu is not behind any other part of the Empire in its industrial progress, and occupies a unique position in regard to coal-mining.

The development of the coal-mining industry in North Kyushu is, indeed, remarkable. In 1886 the whole output of coal did not much exceed

FIG. 24.—THE SEA-COAST OF AKASAKA, MOJI.

three hundred thousand tons, but by 1910 the amount leaped up to the respectable figure of over eight million tons; in other words, an increase of two hundred and seventy per cent. in twenty-five years. North Kyushu contributes more than half of the whole production of coal in Japan. North Kyushu's pre-eminence as a coal producing center is, indeed, such, that Moji and Wakamatsu are now the premier coal-markets of the whole Far East.

I do not mention these facts in any spirit of local self-glorification. I do so, because our guests hail from that great country which, more than any other Occidental State, has laid us under lasting obligation in connection with the development of our coal-mining industry. It is from the United States, especially from your Institute, that we have received most inspiration and help in the improvement of the method of mining.

It, therefore, affords us particular pleasure and satisfaction to welcome

you, the members of the American Institute of Mining Engineers and their friends. We wish to take this opportunity of thanking you and through you the coal-mining concerns and experts of America for all the suggestions and assistance that have been so freely given us.

I propose the health of our distinguished guests.

President Hunt responded as follows:

President Aso and Members of the Chiku-ho Coal Mining Association, Ladies and Gentlemen: It is my pleasant duty as Acting-President of the American Institute of Mining Engineers, to thank you not only for the

FIG. 25.—SHUMPANRO, SHIMONOSEKI.

Where treaty concluding the China-Japan War was signed.

FIG. 26.—ROAD SCENE, NEAR SHIMONOSEKI.

hospitality of this evening, and your President's most gracious words of welcome, but also to thank you and the other citizens of Moji for the unexpected and impressive greeting which was accorded us on our arrival in your busy harbor this morning.

During the day we have visited the Imperial Steel-Works, and were much interested by what we saw in the works, but also by the evidences of great commercial activity which make this part of the Empire so impressive. Indeed, sir, we have felt all day very much at home through breathing what seemed to be an American atmosphere. Certainly in all of our boasted American push, enterprise and accomplishment it will trouble us to find an instance of faster and greater growth than is shown by the city of Moji. I am assured that thirty years ago its site was mostly a neglected swamp, with a few rice-fields scattered through it. To-day it has thousands of busy inhabitants, and millions of dollars' worth

of trade; all due to the energy and successful enterprises of the members of your association. No wonder we have felt as though we were in a home atmosphere!

All of our visit to Japan has been most interesting and delightful, and certainly our journey through the Inland Sea was one to be long remembered. We saw new Japan at Shisaka Island, and later in the same day went back to old Japan at lovely Miyajima, and again to-day we are in touch with the new and energetic enterprise and talent, which is keeping her in her acquired place with the foremost nations. So near here that you heard the sound of the guns, was fought one of the most decisive naval battles in history. By the force of arms your country won its place; by the arts of peace, you are helping to keep it, and in peace and friendship may our two nations be ever united in a common effort for the advancement and betterment of humanity!

Prof. Joseph W. Richards, Vice-President of the Institute, expressed the pleasure all felt at being in such a busy, industrial, coal-and-iron producing district. After visiting Tokyo, the "Washington of Japan," and Kyoto, the "Boston of Japan," they were now in a district which could very properly be called the "Pittsburg of Japan." The visit of the morning to the Yawata Iron Works was indeed a revelation of what advances the Japanese were capable, a people who only fifty years ago were a hundred years at least behind Europe in industrial development. If this rate of progress were maintained, fifty years hence might easily see the Japanese our superiors.

Speaking of the steel-works, their chief characteristic from an American point of view was the predominance of German design and running. The blast-furnaces, for instance, were not of the modern American type, and most certainly would, in the United States, be "driven" much more rapidly. With a blast-pressure of from 10 to 15 pounds per square inch, furnaces would, in the United States, be producing half again as much pig-iron as with their present pressure of from 5 to 6 pounds. Similarly, the Bessemer converters were, from the American standpoint, run at a rather leisurely pace.

On the other hand, the quality of steel produced at the works was certainly beyond reproach, and reflected great credit on the skill of the engineers and staff of the works.

The Mayor of Moji read an address of welcome, and W. L. Saunders, past Vice-President of the Institute, made an appropriate reply, paying special tribute to the remarkable progress and the admirable characteristics of the Japanese people. A photograph of the party was taken and geisha dances followed. At 9.30 p.m. the guests were conveyed to Shimonoseki in a steam launch, wondrously decorated with paper lanterns, on which the American and Japanese flags were painted. The gunwale and sides of the vessel were covered with chrysanthemums, and farewell fireworks filled the sky. The special train left Shimonoseki at 10.50, amid Banzai from both sides, and the waving, by the departing visitors, of the lanterns which they had meanwhile received as souvenirs.

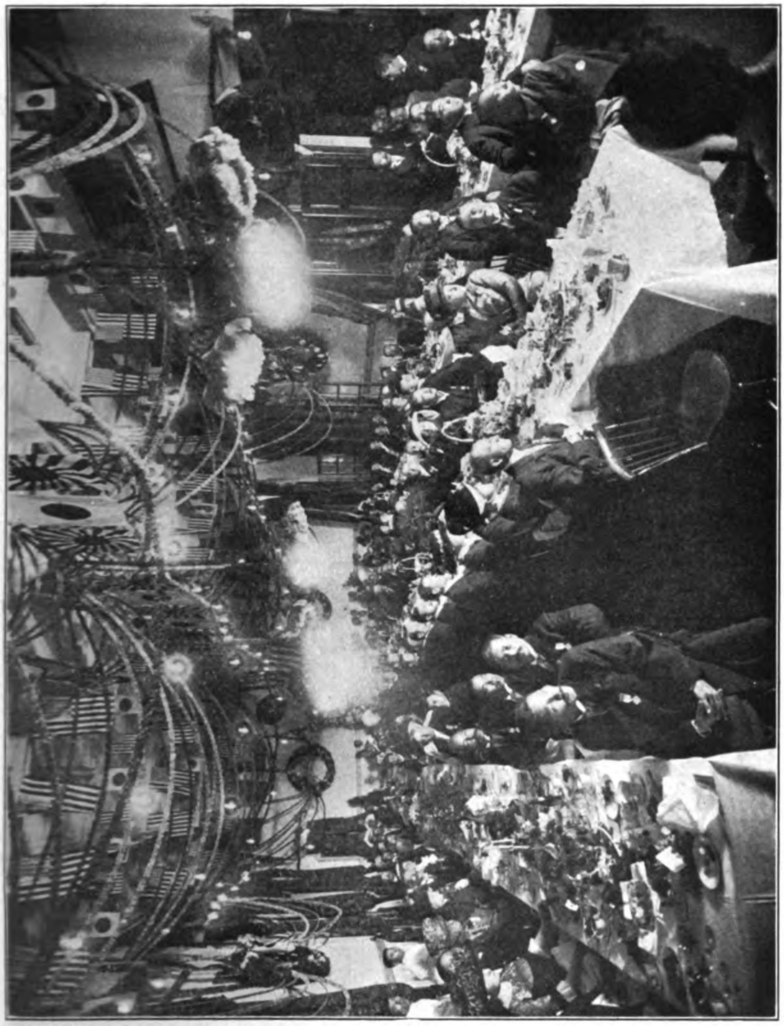


FIG. 27.—BANQUET AT THE MOJI CLUB.

Osaka.

Kobe was reached on Sunday afternoon, and the party was divided between the Oriental and the Tor Hotels. Monday morning, Nov 13, the train proceeded to Osaka, where the day was spent. A reception was given at the castle by the Mayor and the party was later received by the President of the Chamber of Commerce at the Osaka mint, where silver memorial medals were presented to members and guests. In reply to the Mayor's address, President Hunt said:

Mr. Mayor, President Doi: Speaking for our party, representing as we do the American Institute of Mining Engineers, it gives me great pleasure to thank you not only for your gracious expressions of welcome, and

FIG. 28.—THE STATION AT SHIMONOSEKI.

the beautiful souvenir medals struck at your national mint, which you have given us, and which we shall highly prize, but also for your hospitable reception, and the opportunity given us to inspect your historic old castle. A visit we shall long remember, not only on account of its celebrity, but also as having shown us some of the marvels of old engineering accomplishments, and also afforded us a comprehensive view of your great city.

The sight of its many active chimneys, and recalling that our ride from the railway station to the castle gates had been through streets crowded by the press of trade, and in many places faced by tall and substantial modern commercial buildings, and several of the streets wide enough to operate safely an electric double-track street-car system, but beyond all the sight at several points of apparently good buildings being torn down to be replaced by more modern ones, made me, a resident of Chicago, fully realize why Osaka has been named the "Chicago of Japan."

Gentlemen, your city has had a life of hundreds of years, while ours is only of yesterday, but revived and made prosperous by your modern civilization and accomplishments, you stand triumphant, and young Chicago claims brotherhood with old Chicago in her renewed youth.

Again we thank you all for your hospitality and beg to hope for your city's continued prosperity.

The party was then taken to lunch at the magnificent residence of Baron Fujita. The Baron being unfortunately prevented by illness, his son, Mr. Heitare Fujita, and Madame Fujita received us; and Mr. Fujita welcomed us in fluent and excellent English, making special reference to Dr. Raymond, President Hunt, Past-President Brunton, Secretary Struthers, and Past-Manager Goodale, of the Institute, as having extended courtesies to Japanese students and engineers visiting the United States.

FIG. 29.—MEDAL PRESENTED BY MUNICIPALITY OF OSAKA.

President Hunt replied as follows:

Permit me, on behalf of my fellow-members of the American Institute of Mining Engineers and their friends, who are your guests to-day, to thank you for your most gracious and elegant hospitality, and also to thank you, sir, for your friendly words of welcome.

As we entered your doors we all felt the effects of the peculiar and restful feeling of being at home, and now that you have mentioned the fact of your being a fellow-member of our Institute, the cause of that feeling is made plain—we are in the home of a brother.

You were good enough to speak most appreciatively of favors extended to some of your representatives while visiting America, and named some of those who were of service to them in their professional investigations while in that country. I am happy to inform you that several of those gentlemen are your guests to-day, and I am certain they have been much gratified by your kindly words. I am also positive that it has not only

been a pleasure to those of us who have had an opportunity of trying to assist visiting Japanese friends, but I can assure you that after the welcome and hospitable treatment which we are receiving in this country we shall feel that it will be impossible for us ever to do enough for them in the future.

We are extremely sorry to learn of the illness of your father, the Baron, and request you to present our respects to him, with our best wishes for his speedy recovery.

Hoping you will soon exercise your rights as a member of the Institute by personally visiting its headquarters, and while in America letting each of us have you as our guest, I again thank you and beg to propose the health of our host and hostess.

Past-President Brunton and Dr. Joseph Struthers, Secretary of

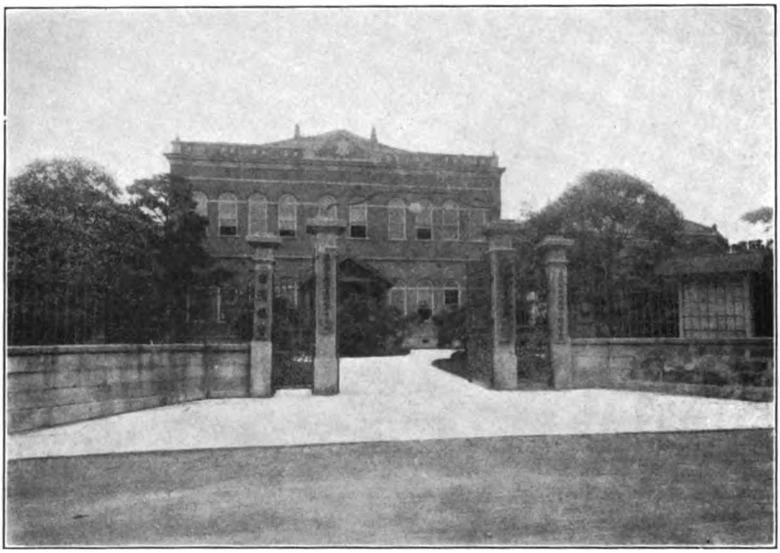


FIG. 30.—THE CHAMBER OF COMMERCE, OSAKA.

the Institute, being called upon, made brief remarks, acknowledging the complimentary mention which had been made of their names.

At 1.30 p.m., the train proceeded to Suma, arriving at 2.30, to attend a garden party given by Baron Sumitomo, who, with his daughter, received and entertained us with graceful tact. Among other things, we were permitted to see the operation of seine-fishing and the work of brush-painting performed before our eyes. Then there was a dinner at which Baron Sumitomo welcomed us and President Hunt again replied:

Baron Sumitomo, Ladies and Gentlemen: Again, as the Acting-Presi-

dent of the American Institute of Mining Engineers, it is my pleasant duty to return the thanks of our party to you, Baron, for your warm welcome and most delightful hospitality.

We have been enjoying a voyage through Japan's beautiful Inland Sea, and it is a happy coincidence that our first day of it was inaugurated by partaking of your company's hospitality on Shisaka Island, where we also, as engineers, had the pleasure of examining copper-smelting works of the most complete and advanced character. And now to-day we are having our last look at that sea as your guests at this charming villa, where you are doing so much for our pleasure and entertainment, even going so far as to compel the fishes of the sea to yield up their lives by a most picturesque agency.

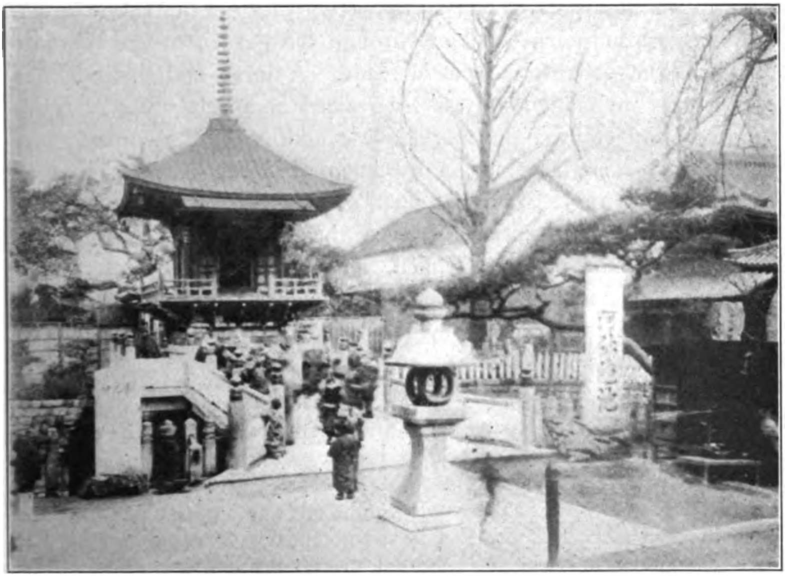


FIG. 31.—THE AMIDAIKE (WAKOJI TEMPLE), OSAKA.

Our welcomes have been frequently coupled with a hope and belief that such visits as ours must tend the more closely to unite America and Japan in commercial relation and the bonds of friendship. I can assure you, sir, that we fully concur in that sentiment, and also feel that through the courtesies which we have received we have gained a knowledge of and respect for Japan that could not have come to us in any other way.

Again I thank you, and have the honor to propose your good health, long life and happiness.

Brief remarks were also made, in response to informal calls, by Messrs. Saunders, Struthers, Goodale, Wiley, Wolf and Richards.

Tokyo Again.

The night was again spent at Kobe, and Tuesday, Nov. 14, was occupied in the return trip to Tokyo, which was reached late in the evening.

On Wednesday, Nov. 15, the Imperial garden-party took place in the spacious and beautiful grounds of the Asasaka Palace of the Crown Prince. The Emperor being absent, in attendance upon the military maneuvers in Western Japan, the Empress, together with the Crown Prince and Princess, and other members of the Imperial household, received those who had been invited to an audience, among whom were Captain and Mrs. Hunt and Dr. and Mrs. Raymond. All of the party had an opportunity to see the Empress and her suite as they went on foot through the garden to the marquee in which the presentations were made. A large and distinguished company of invited guests was entertained at an elaborate *al fresco* collation, and enjoyed the marvelous exhibition of chrysanthemums. (One truly imperial plant, a specimen of *Hana Kazura,* was 18 ft. wide and bore 724 blossoms upon one stem!)

At 3.30 p.m. a reception, given at the Tokyo Chamber of Commerce, was numerously attended, and proved highly interesting. President Nakano made in Japanese an address of welcome, which was translated into English by the Secretary. President Hunt replied as follows:

President Nakano, Members of the Tokyo Chamber of Commerce, and Gentlemen: Again it is my pleasant duty to return thanks for the members of the American Institute of Mining Engineers and their friends who are to-day your guests.

The word welcome has become a familiar one to us since we have been in Japan, but I assure you it has not possessed greater value than when used towards us by so influential an organization as your own. We have been in your country only a few days, but they have been busy ones, and everywhere we have been the recipients of great hospitality and many acts of consideration.

We have visited your most ancient and classical places and some of your modern and most progressive centers of commercial and industrial activity, and been made to feel that we were not strangers in a strange land; and whether as we passed through your farming country or in your crowded cities, we have been everywhere impressed by the industry and apparent contentment of your people.

We thought we knew you, from our somewhat infrequent meetings in America with some of your people, and our reading of your history, but now realize as never before the truth of that which you so well stated, that it requires actual personal intercourse to make people of different nations understand each other.

We regret that the balance of trade between our two nations is so much against our own, but the truth is that with our great natural resources and our rapidly increasing population, our manufacturers and merchants have been almost always satisfied with their home markets, and have as a rule only sought foreign ones when from some cause our own failed to consume their output. If they expect and want to command foreign markets they must learn that they will have to give them constant attention and protection. If periods occur, as they will and must, when export trade does not pay so well as the other, they must bear the loss, and thereby retain their customers, and depend upon the profits from other seasons to recoup them. Moreover, they must learn to make that which a foreigner wants, and not try to force him to buy that which they want to make. I believe our people are learning these lessons, at least I hope so.

The Pacific ocean, to which you have so poetically referred, does separate us, and it is also a means of connecting us, and when united with the Atlantic as it will soon be, our countries should be drawn yet closer together, not only commercially, but also in friendship.

Standing as they both do for the betterment and advancement of humanity, they are now friends, and I for one cannot see any cloud in the political sky which betokens any storm calculated to disturb that relation. Let us hope it may never come.

President Nakano then introduced Dr. Soyeda, President of the Industrial Bank of Tokyo, who delivered in English the following address:

It is my most pleasant duty to offer, on behalf of the Tokyo Chamber of Commerce and as one of its special members, a sincere word of greeting and welcome to our guests, who have come from the other shores of the Pacific.

It was about a half century ago that our long closed sea-gate was opened to the intercourse of the world, when the country represented by our guests assembled here to-day played a most conspicuous part. We have since then been indefatigable and earnest in our efforts to promote progress and effect reforms in all fields of activity, especially political and economic.

That peace and tranquillity, for such a purpose as ours, is and has been most necessary goes without saying. If we have had, in the past, to take up arms, it has never been for any aggressive or selfish purpose, but in self-defense for the preservation of peace.

Now it is well known that peace is the result of and maintainable only through amicable relations and intimate knowledge of one another among the so-called leading Powers; but such relations and knowledge can arise only from international inter-weaving of commercial, industrial and other peaceful interests; and our desires and aspirations lie consequently most intently in those directions.

As individuals are often subject to nightmares, so are nations. Wild and groundless talk of war between the United States and Japan is one of the instances. What are we to fight for? Is it about China? But the Open Door, territorial integrity and equal opportunities are our established

policy toward our western neighbor on the continent. If I am not mistaken, the same is the case with our eastern neighbor across the Pacific. Thus we both are agreed, and have nothing to quarrel about in this connection. What else is there to arouse their hostilities against each other? Is it the labor-question? We ourselves have gone further than all fair-minded Americans had expected in restricting the flow of Japanese immigration into the United States. Nations will not and must not fight without a clear reason and just cause. Nothing of this nature exists between us, and it is evident that the wild talk is merely an invention of mischief-makers and of people influenced by some selfish motives.

At all events, we have had till now a good deal of war scare. Let us now have sounder and fairer and truer views prevail in both countries, so that there will be no room for mischief-makers to indulge in their infamous work. For that purpose, facts are more convincing than mere words; and our guests, being actually here and seeing for themselves how we think and what we intend to do, will do much in dispelling the mistaken views about us, when they get home and have opportunities to present facts and nothing but facts to their relations and friends.

Your coming over to us then will surely bear great and good fruit in strengthening friendly relations, existing ever since the opening of our country; nay, further, it will help much the maintenance of peace, and therefore commercial and industrial intercourse on the Pacific, to the mutual benefit of the innumerable population on the shores of that vast water highway, which when connected with the Atlantic by the completion of the Panama Canal, will bring together the four continents into almost direct contact with one another and assimilate the greater part of mankind into one family group, thereby ending wasteful armaments and bloody wars.

Before concluding, allow me to express again our hearty welcome to our guests, coupled with our ardent wishes that they will use their efforts and influence for the furtherance of the commercial and industrial intercourse of the United States and Japan, thereby strengthening the cordial intimacy that has existed for years in the past, and ought to last for ages to come.

President Hunt requested Dr. R. W. Raymond, Past-President and Secretary Emeritus, to respond. Dr. Raymond spoke substantially as follows:

Mr. President, Your Excellencies, Japanese Friends, Fellow-Members and Guests of the Institute, Ladies and Gentlemen: I count myself happy in the privilege of replying, for my brethren as well as myself, to the wise and friendly utterances of the representatives of Japan; and am doubly grateful that the words which they have spoken, like the words which I shall speak, find utterance beneath the roof of a Chamber of Commerce. We sometimes hear commerce disparaged, as less honorable or illustrious than literature or art or war. But commerce is, in fact, the one great factor of human peace and progress. Commerce cannot exist between enemies; it demands, before and above all, as the basis of its very existence, the mutual, honest friendship of men and of nations. There can be no enduring commerce of which the benefits are not felt by both parties. Anything else is but temporary plunder of one party by the other.

Consequently, the rule of a true and lasting commerce is the Golden Rule of Confucius and of Christ. And, therefore, as the representative of a profession which belongs to the great army, and is engaged in the great campaign and conquest of peace, I am grateful and proud to exchange fraternal messages with the representatives of commerce.

Just before we sailed from San Francisco, the President of the United States broke ground in San Francisco for the great Panama-Pacific Exposition of 1915, which is to celebrate the completion of the greatest engineering enterprise of history—the Isthmian Canal—accomplished by the energy and skill of American engineers. As Mr. Taft, with silver spade, performed that ceremony, the flag of our country was unfurled over his head, and at the same moment a flight of innumerable doves was let loose. As I have said on another occasion, I would now say again that, with all my heart I pray that these white birds may prove to be the symbols of countless kindly thoughts and words, crossing and recrossing the great Pacific sea, bearing from us to our friends, and bringing from our friends to us, the olive branches of peace!

Since I first uttered this aspiration, I have learned that, in the old Japanese mythology, the dove was, for some mysterious reason, regarded as a messenger of the god of war. But that part of the old mythology was drowned fifty years ago, in the flood of progress; and the dove has survived to fly on a better errand!

At the invitation of Mr. Nakano, President of the Tokyo Chamber of Commerce, Professor Baron Kanda spoke *extempore* as follows:

Mr. Chairman, Members of the American Institute of Mining Engineers, Ladies and Gentlemen: After all that has been so eloquently spoken by the previous gentlemen there seems to be but little left for me to say. Besides, I am neither a mining engineer nor a business man; nor have I the good fortune of being a bank president. But the fact of your distinguished party visiting our city at this season of the year, when nature has put on her gorgeous robe, and the sight of the procession of your automobiles going the rounds of sightseeing with the Rising Sun happily mingling together with the Stars and Stripes—all brings back vividly to our minds our ever-to-be-remembered experience in your country two years ago, when the party of the Honorary Commercial Commissioners, headed by Baron Shibusawa, here present, made the tour through that splendid constellation of cities, viewing the wonders of nature as well as the equally wonderful works of man. As a member of that party, I wish to tell you with what keen pleasure we cherish the memory of that tour so well planned out by Mr. J. D. Lowman, President of the Seattle Chamber of Commerce, and other gentlemen of the Committee, that there was scarcely a hitch in the whole programme, covering three months, during which we were overwhelmed with courtesies and hospitalities at the hands of your countrymen throughout the length and breadth of the great continent. If we had wanted any testimony of the traditional good-will and friendship of the people of America towards those of Japan we certainly found it then and there. And we who brought back such

delightful impressions have communicated them to our fellow-countrymen on our return, and have thus been instrumental in imparting a better knowledge of your country, of your people and how they feel towards us, etc., so that the two peoples have been bound in a closer bond of friendship than ever before.

Emerson says in one of his essays that as many countries as one sees, so many times is he a man. There is nothing like foreign travel for driving out of our heads the nonsense of the wigwam. Now, I do not mean to imply that when we welcomed you on our shores you were all single men in any sense of the word. You had already doubled and trebled yourselves through extended travels across the Atlantic. But I understand that this is your first trip across the Pacific. We are proud to have had the pleasure and privilege of giving you your first Asiatic coating. Let us hope that your impressions of the country and its people have been such that you may be tempted to take another coating again in the near future.

Ladies and gentlemen, I said I was not a mining engineer, and I do not know much about mining or of any of the precious products of mines, but I do know that you engineers can make the earth yield a substance which can be smelted, forged and welded in chains and cables that will hold gigantic ocean liners to their mooring, that will hold the parts of your forty-story buildings or the immense spans of your suspension bridges together. But, ladies and gentlemen, you have by your present visit forged a cable eighty strands strong—a bond far more powerful than that of iron or steel, which will hold the two nations together in the bonds of lasting peace and friendship. To-morrow you are to start for the remainder of your sight-seeing—to Nikko, the Ashio copper-mines and the Hakone mountains. Well, I can only say the best is reserved for you. We have a saying in Japan that those who have not seen Nikko cannot say "kekko" (beautiful), for they don't know what beautiful is. Besides, think of a party of mining engineers up in the mountains! You will, like fish in water, find yourselves in congenial elements, a fitting climax to your Japan excursion of 1911. Well, after all you have seen and done, and after you have safely returned to your dear old homes, whenever you recall your visit to Japan, may you always think of our hearts as being as red and warm towards you as those magnificent maples in the Imperial Garden, which we visited this afternoon.

Vice-President Richards, being requested to reply, remarked upon the intimate connection between the development of the mineral wealth of a country by its mining engineers and metallurgists, and the economic and political independence of the land. The amount of agricultural land in Japan being but a small proportion of its area, it appears probable that the food supply will never be more than sufficient for the needs of the Japanese, and it follows that increase of national wealth must, therefore, come from exploitation of natural mineral resources or from manufacturing. While the latter may ultimately be the great factor in the development of Japan, yet the immediately practicable and surest extension of national activity is in the line of mining and metallurgy. It was pleasing to know that the financiers and statesmen, as well as the mining engineers and metallurgists of Japan, understood this situation, and were so actively

developing their mines and smelting-works. It was gratifying also to observe that in this development they were utilizing to a large extent the experience and learning of Europe and America, adapting it with great skill to their particular problems. It was to be hoped that they would continue doing this in the future as actively as in the past, for no civilized nation could afford to cut itself off from the progress of the rest of the world or pretend to develop independent of outside assistance. They should, therefore, continue to employ some foreign professors and engineers, to send their own students and engineers abroad, and so as actively as possible keep up that interchange of intellect and scientific experience which is much more fundamentally important to Japan than the bags, bales and boxes of ordinary commerce.

In the evening a theater-party was given at the Imperial Theater by Baron Iwasaki, Baron Mitsui and Mr. Furakawa. The large opera-house was decorated with flags and magnificent banks of chrysanthemums. Three plays were given, an English synopsis of which was furnished to each visitor, and after the performance a supper was served to several hundred guests, including the *élite* of Tokyo, as well as the visitors from America. The best actors on the Japanese stage had been specially secured for the occasion, and there was some capital acting according to our own standards, though the general impression produced by the plays—one of which might be called a comedy, another a tragedy, and the third a legendary melodrama—was strange and bewildering. Altogether this was one of the most interesting episodes of our visit.

Nikko.

On Tuesday morning at 8.50 the special train left Tokyo for Nikko, which was reached early in the afternoon. The journey lay through a fertile and highly cultivated country, gradually ascending to the Nikko mountains.

At Utsunamiya, the capital of the Tochigi Prefecture, Messrs. S. Honiguchi, Assistant Governor; R. Honda, Mayor; H. Saida, Assistant Mayor; K. Ishikawa, President of the City Council and the Chamber of Commerce, and other local officials, boarded the train with a cordial greeting.

Later, at Fubasami, Messrs. K. Sasaki, President, and J. Tamura, Vice-President, of the Town Council, together with several members of that body, paid a similar tribute of courtesy. A unique basket lunch, served upon the train, won universal admiration—baskets and contents alike.

At the Nikko station Messrs. K. Nagai, Chief Magistrate of the county; H. Nakatsugawa, Chief of Police, and other officials, with a large delegation from the Furukawa Co., received the party.

This delegation included Messrs. S. Nishiyama, President, and U. Muramatsu, Manager, of the Nikko Electric Railway, and the following officials of the Furukawa Co.: K. Okumura, Manager of the Nikko works; J. Kojima, Superintendent of the Ashio copper-mine; K. Nakai, Superintendent of the Engineering Department; K. Hasegawa, Superintendent of the Honzau mine (Ashio); U. Tsukagoshi, Assistant Superintendent of the Ashio smelter; K. Yamaguchi, Assistant Manager of the Mining and Engineering Department; T. Fujibayashi and S. Furusho, engineers, and N. Fukuchi, geologist. Mr. Masayuki Otogawa, a director and consulting engineer of the company, being a leading member of the Japanese Reception Committee, was, of course, already with us.

Boarding the special cars of the Nikko Electric Railway, we were conveyed through the narrow main street of the town, lined with smiling faces and bright with flags, past the hotels and the sacred bridge, to the copper-refining works of the Furukawa Co., about 5 miles from the station. The works were adorned most ingeniously with emblems of welcome, mostly constructed of copper. There was an arched bridge, built of copper ingots, and thrown across an azure lake of crystals of copper sulphate. Greetings expressed in metallic copper appeared everywhere. The signs indicating the course to be followed in inspecting the establishment were not hands pointing with index-fingers and saying "Go that way!" but open hands, beckoning, "Come this way!"—a delicate and characteristic difference. Our arrival at the works was signalized by the firing of rockets, etc. As usual, the coupled flags of Japan and America were in evidence everywhere. After the works had been inspected a collation was served in a marquee erected for the purpose, at which President Hunt addressed Mr. Otagawa as follows:

Mr. Otagawa: Speaking as I do for those who for so many days have had you for a traveling companion, and have so constantly been made more comfortable, and our visit to Japan made more profitable, through your constant thoughtfulness, I do not know how I can find words to express properly not only our thanks for this last evidence and assurance of your friendship, but also for all that has gone before. It is simply an impossible proposition; I cannot do it.

From what we have seen in the works just examined, and what we are now enjoying, I am inclined to suspect that during our visits together to the previous places of interest you have been carefully making notes, so that when at last this time came you might be able to give us just a little bit the best of all.

We admire your plant and have taken great interest in the inspection

of its various departments, and desire to thank the Furukawa Mining Co. for having given us the privilege.

Some of our members are yet to have the pleasure of visiting some of its mines and smelters, and we regret that a greater number cannot do so, but are glad that the gentlemen who will make the examination are men of large mining and smelting experience, and therefore fully competent to appreciate what is shown them.

Through you, we want to thank the other officials of your company for their attentions, and desire to compliment the workmen of this plant for the artistic welcoming arrangement which they formed from some of its products.

It is sad to think that in so short a time we must part from you, sir, whom we have learned to regard as a friend; but grief is sometimes hidden by forced laughter, and, that we may disguise ours by noise, I ask our party to give three cheers and tiger for you and your company.

Mr. Otagawa replied in English, expressing his thanks for the salutation given him, and explaining some of the plans prepared for the enlargement and improvement of the company's works at an early day.

Dr. Raymond spoke as follows:

Artemas Ward once said that "an occasional joke looked well in a comic paper!" In the same spirit, I venture to say that a traveling party of mining engineers and metallurgists may with propriety visit, now and then, a mine or a smelting-works! And I am very glad that we have to-day discharged this most appropriate and pleasurable function by visiting these works of the company with which our friend and fellow-member Mr. Otagawa, is connected. I have known Mr. Otagawa longer, perhaps, than any of you other members of the Institute have known him. While he was sojourning in the United States, and gathering by study of our American practice that knowledge of which the results, with some improvements "bettering instruction," have been shown to us to-day, he was a frequent visitor at the office of the Institute, and I learned to regard him with an esteem and admiration which became the beginning and basis of the high opinion whch I have come to entertain concerning Japanese mining engineers and metallurgists as a class. In addition to our acknowledgment of the graceful and generous courtesy of the Furukawa Company, and of all its officers, already suitably expressed by Captain Hunt, I beg to emphasize two features of this occasion, which seem to me significant.

The first is, that we have seen this afternoon a copper-refinery embodying not merely the details of modern practice, but also some improvements which are original. I may mention as an instance the casting-apparatus, which impresses me as the simplest, cheapest and most satisfactory I have ever seen, and which, as Mr. Otagawa has informed us, is the invention of Mr. Kaku, a Japanese metallurgist.

And the second is, that we have been enabled to see the whole of this establishment—the casting of the copper electrodes, their electrolytic refinement, the manufacture of plates and rods and the drawing and testing of wire—with an unprecedented economy of time and strength on our

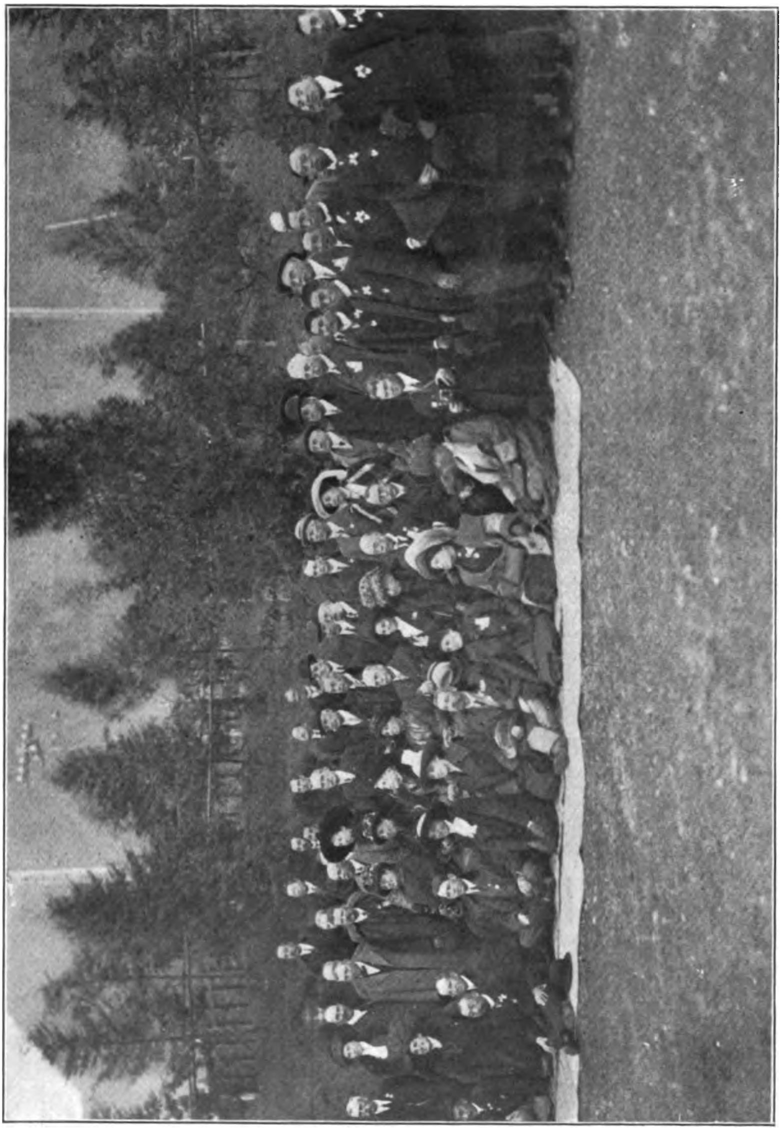


Fig. 32.—Group of Members and Guests at Nikko.

part. I beg to say, as an expert, that, in my judgment, a process in commercial operation which can be so clearly and comprehensively exhibited in so short a time has been well designed and is well managed!

Vice-President Richards, being called upon, made a few remarks:

He congratulated the Furukawa Mining Co. on their enterprise in refining their own copper, and, still further, on their policy of manufacturing this copper into its final forms. The Japanese are particularly clever workmen, and the growth of modern manufacturing plants in Japan must be looked upon as the ultimate goal of Japanese industrial policy. Japan is destined to become a great manufacturing nation, and when she has learned to work up her own crude material into manufactured articles she will follow by working up the crude materials of other countries, until she becomes the chief manufacturing country of the Orient.

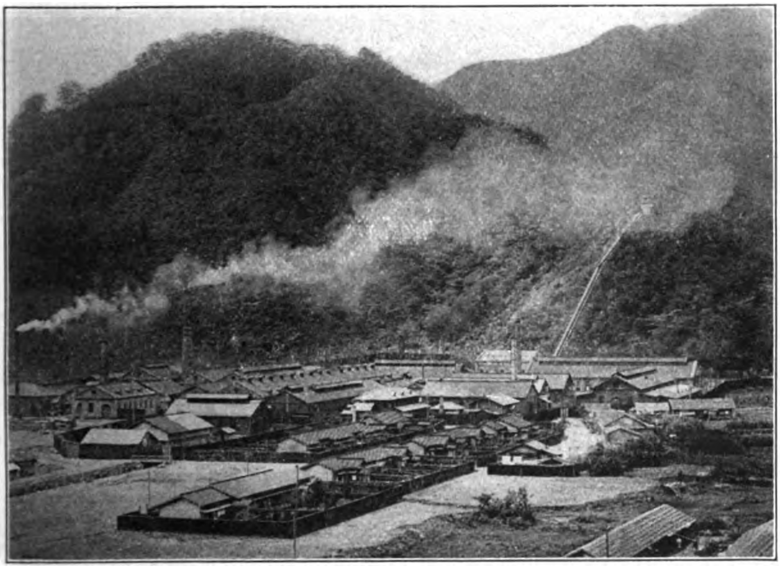


FIG. 33.—THE NIKKO COPPER-WORKS.

Referring to the copper-refining at Nikko, the operation of casting the copper, by Mr. Kaku's simple but efficient machine, was something which metallurgists could appreciate as a beautiful adaption of means to end, and worthy of high praise. At Ashio also, which some of them would see, there were "wrinkles" to be seen which would give the visitors something to take back home with them. Altogether, it could be said that in some respects the Japanese metallurgists were improving upon their preceptors, and who knows but that in the future we may be found coming to Japan on purpose to learn something new and useful in our own special lines.

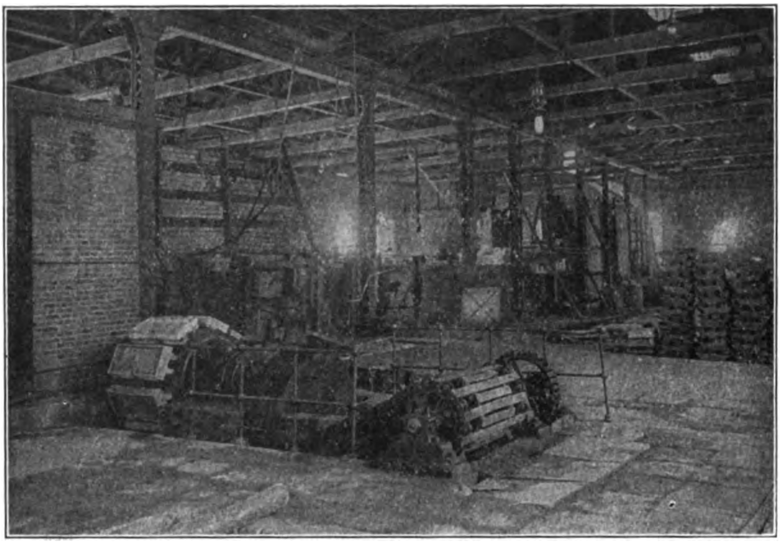


FIG. 34.—FURNACE-HOUSE, SHOWING CASTING-APPARATUS, NIKKO COPPER-WORKS.

Returning to Nikko, the party was divided between the Nikko and Kanaya hotels, both of which proved exceedingly pleasant and comfortable.

Friday, Nov. 17, was spent in visiting the splendid temples and shrines of the locality. The grand, dark groves of gigantic *cryptomeria,* the autumn colors of the maples, the sparkling cascades, tumultuous river and lofty heights formed a unique and indelible picture.

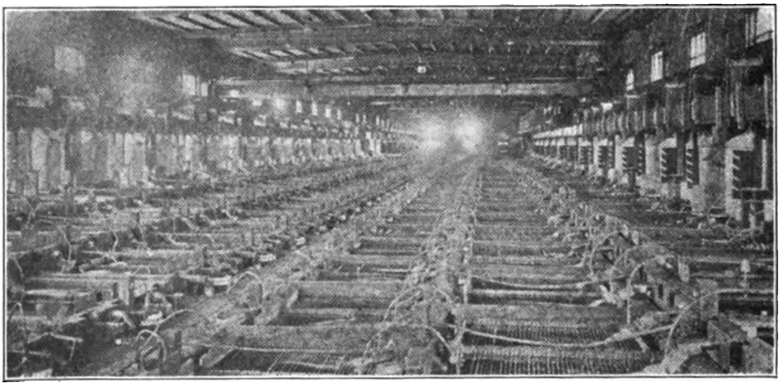


FIG. 35.—TANK-ROOM, NIKKO COPPER-WORKS.

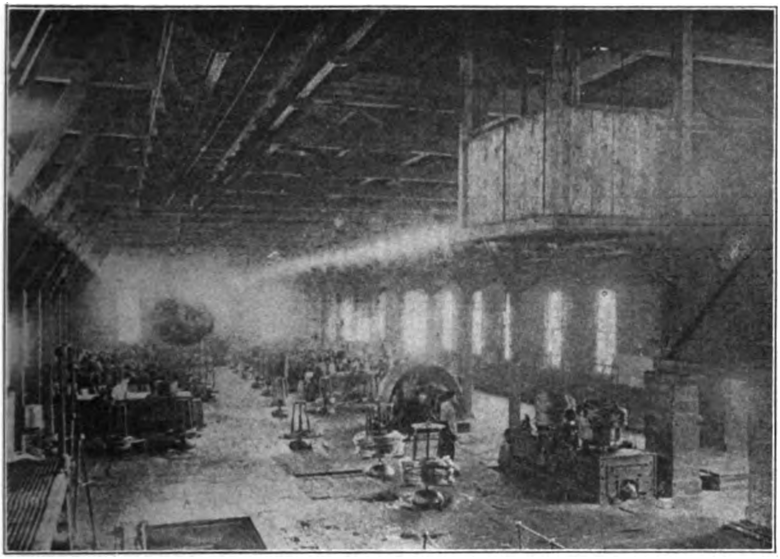


FIG. 36.—WIRE-DRAWING ROOM, NIKKO COPPER-WORKS.

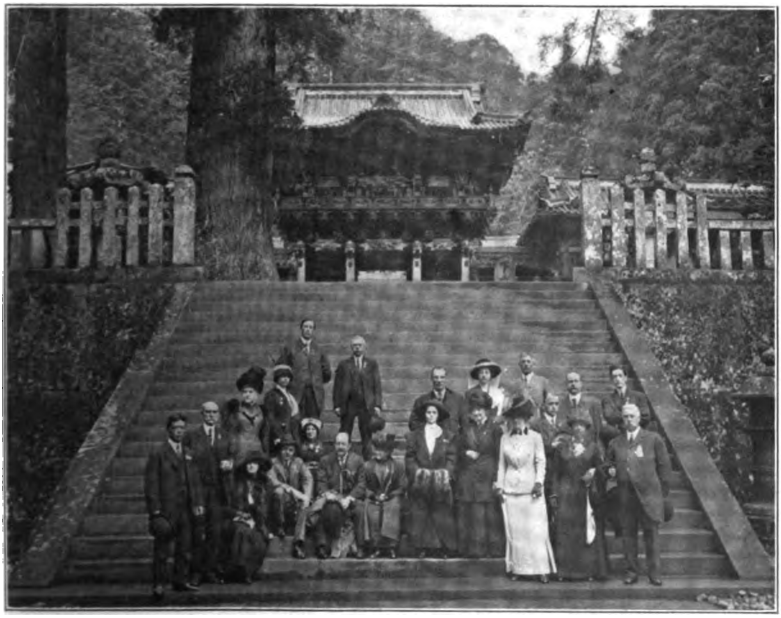


FIG. 37.—GROUP OF MEMBERS AND GUESTS ON STEPS OF SHRINE OF TOSHUGO, NEAR NIKKO.

FIG. 38.—PAGODA AT NIKKO.

FIG. 39.—CRYPTOMERIA ROAD, IMAICHI, NIKKO.

Saturday morning, Nov. 18, the party left Nikko at 8 o'clock, and reached Ofuna at 1.46 p.m. Here it was divided into two sections, A and B, both of which visited Miyanoshita and Kamakura, though in opposite order, reuniting at Ofuna on Monday, Nov. 20.

Miyanoshita.

The Fujiya Hotel at this place was unanimously voted one of the

FIG. 40.—THE SACRED BRIDGE, NIKKO.

finest in Japan, and the long trip by train and jinrikisha from Odzu to Miyanoshita presented, in its Tyrolean picturesqueness and loveliness, the climax of scenic attraction.

Kamakura and Enoshima.

At Kamakura, the large and comfortable Kaihin-in Hotel entertained the party delightfully. The Temple, the Great Buddha, and the island of Enoshima were visited and admired.

Yokohama Again, and Farewell.

The reunited party reached Yokohama on Monday, Nov. 20, and was quartered at the Grand Hotel. The rest of the day was spent in

FIG. 41.—THE FALLS AT HAKONE.

FIG. 42.—THE DAIBUTSU AT KAMAKURA.

visiting the fine shops of the city, and in preparations for embarkation on the morrow.

On Tuesday, Nov. 21, a farewell luncheon was given by the visitors to the representatives of their hosts, a large delegation of whom came over from Tokyo and other places to be present. This was the only return-courtesy that we were permitted to extend to them; and it was only after long argument and upon strong persuasion that they surrendered the privilege of being our entertainers to the end. But

we carried our point at last; and a strenuous day was spent in preparing the feast, sending telegraphic invitations, etc.

By an inspiration on the part of Mr. Manwaring, the manager of the hotel, a decoration of the great banqueting-hall was devised which our Japanese friends, with all their ingenuity, had not employed at any of the score of entertainments given in our honor, namely, in addition to the familiar flags, massed chrysanthemums, and trailing vines on the tables, the hall was turned into a vast bower by graceful over-arching bamboo trees. An admirable dinner and a happily sentimental and appreciative company perfected this final festivity.

President Hunt proposed a toast to the Emperor of Japan, which was drunk standing, while the orchestra played the Japanese national anthem. Baron Shibusawa replied in an eloquent address (translated by Mr. Zumoto, editor of the *Japanese Times,* of Tokyo, proposing the health of the President of the United States, which was similarly honored. Baron Shibusawa said:

As representative of the Welcome Committee, I feel I am highly honored to bid you good-by. Your party, which we had been awaiting with almost impatience, at last came; but you are now to leave us before the word of welcome has died upon our lips. Your stay in Japan has not been long, but during these twenty days you have seen Tokyo, Yokohama, Kyoto, Osaka, Nikko, Hakone, Moji, some parts of Kyushu and some other places. Thus we believe the time which was at your disposal has been spent most enjoyably and economically, and we trust you have observed much.

We fear only that our reception has not been such as it might have been, and we regret that the shortcomings on the part of our Reception Committee have been so many. At any rate, we believe you found satisfaction in two things: In the first place, you were introduced to the material side of our civilization. You saw our mines, railways, steamers, banks, hotels, theaters—not to speak of many other things. And it is our pleasure and pride to say that whatever we are—that we owe largely to your country. This being the case, we trust that whatever you saw, though it might not have been so complete as could be wished, was highly gratifying for you, inasmuch as it is nothing but the work of your own pupils.

In the next place, you visited Japan at the best time of the year; you saw her at her best. The beauty of the country was in her best robe, and the weather was most ideal throughout your sojourn. It is true that you miss in this country such gigantic and magnificent scenic beauties as Niagara Falls, the Grand Canyon and the Colorado peaks, but Nature has not entirely forgotten to adorn us with beauty.

One other thing must be satisfactory for you to know—that is, that the sentiment of welcome and reception you met everywhere was very sincere. We were prompted only by our true friendship to do whatever we did. We have done what we could in the short time, and if you could not

manage to take home as many presents as you wish, we have to be excused from blame.

To our great regret we hear of war-talk in your country now and then, and we observe that some foolish and sensational jingoism finds its way into print. We also regret to know that our real sentiment is not known in your country so widely as may be wished. But we now know every one of you, and you know us personally; and it is our hope that upon your return home you will tell your friends and countrymen that we are always your friends.

Now, the friendly relations between two countries depend upon mutual understanding, and also upon mutual sharing of interests. For this reason, enterprising business men of your country are invited to invest money

FIG. 43.—SHOOTING THE RAPIDS.

in our business. And when we know each other, and have common interests, then there will be such friendship between us that nothing could impair it.

The toast in honor of the President was acknowledged by Hon. Charles P. Bryan, the new American Ambassador to Japan. Mr. Bryan said, in substance:

In the sight of the Rising Sun and the Star-Spangled Banner the warmest sentiments are always roused within me. I believe there has not been a better President and better friend to Japan than President Taft. When I saw him in San Francisco just before I sailed, he sent a personal message to all Japanese and all leading Japanese whom he had the privilege of meeting during his tour in Japan. Now I, as a personal friend of the President of the United States, hope that the members and guests of the American Institute of Mining Engineers will go home to proclaim the beautiful, magnificent sceneries of Japan and the marvelous energy of the Japanese people. I am sorry that I could not receive you

at my embassy, but you received treatment such as I could not give you. And I trust that when you return you will receive the members of the Japanese Mining Institute on the threshold with outstretched hands, even as they did you. I do not doubt that the royal and princely receptions you have received will please all the people and the President of the United States.

FIG. 44.—COUNTRY SCENE.

President Hunt then spoke as follows:

Baron Shibusawa, Ladies and Gentlemen: We had hoped to have the honor to-day of entertaining all of the officials and more private citizens who had honored us by their hospitality during our visit to Japan, but that was too much to expect from such busy men. All of them who are not with us have coupled with their regrets kindly messages to our party, and wishes for their safe and comfortable journey home.

Their excellencies, the Minister of Foreign Affairs and the Minister of Agriculture, are prevented from being here by a cabinet-meeting, but have honored us by most courteous messages of regret.

We have been enjoying the hospitality of our Japanese brother-members of the Institute and their friends for three weeks—a short time in number of days, but equal to many years in sentiment. To-day it is our privilege to have them as our guests, not that we are trying to cancel a debt, but only that as we have broken their bread and eaten of their salt, so shall they do of ours, and thus effectually seal the bond of friendship.

In all human probability it will be impossible for all of us ever to meet again together, and we of America did not feel satisfied to leave your hospitable land without collectively expressing to you our thorough appreciation of the great kindness which you have extended to us. Everywhere in our journey we have been greeted by the word "Welcome"—generally wrought in your beautiful national flower, and always followed

by a human greeting of sincerity beyond question. Your flowers were bright, but the kindly eyes of our hosts were brighter, and the grasp of their hands was warm enough to wither any flower.

Personally, on behalf of Mrs. Hunt and myself, I want to thank your "Welcome Committee" for the beautiful presents which they have given us. We recognize that they came to us because of our official position, and were therefore intended as a compliment to all of our party; nevertheless we personally prize them, and shall hold them as cherished possessions.

Again I want to thank all whose hospitality we have enjoyed. We wish all of them were here to-day; we realize the impossibility of our wish, but, absent or present, we thank them and beg to assure them that they have made bright spots in our lives which will remain so long as we live.

You have shown us many of your historic and ancient places; we

FIG. 45.—A SEA-COAST ROAD.

have realized their beauty and majesty, and often the sublimity of their environments. Standing amid them, we have striven to recall and appreciate old Japan. We have visited your busy commercial centers, we have inspected some of your mines and industrial establishments, we have passed through your agricultural sections, and everywhere seen your industrious and economical people, and thus seen and learned Japan of to-day.

Through the fearful ordeal of war you have won your place among modern nations. With great wisdom you are striving to keep that place by the arts of peace.

Young America greets old Japan, and in her renewed youth hails her as an equal and desires the two nations to be ever friends.

Speaking for all of our party, we want to especially thank the "Welcome Committee" and their representatives, who have accompanied us,

and so kindly and most considerately borne with us during all of our visit.

Again, and again, we thank all of you.

Prof. Wataru Watanabe, President of the Mining Institute of Japan, being called upon, expressed his regret that Viscount Kaneko could not be present, and expressed the cordial congratulations and farewell greetings of the committee.

Vice-President Richards, at the request of President Hunt, spoke in substance as follows:

We who have had the great privilege of making this memorable visit to Japan, and who now thank you personally for your unstinted hospitality, are but a small fraction of the great society which you are honoring through us. I therefore wish to express to you, our Japanese hosts, the

FIG. 46.—THE FRIENDLY DEER OF NARA.

personal thanks of the absent President of our Institute, Mr. Charles Kirchhoff, for your kindly reception, and also to assure you that more than four thousand members of the Institute, all over the world, appreciate and esteem the honor you have done the Institute in thus greeting and honoring us.

As professional mining engineers and metallurgists, we wish, in parting, to express our great admiration of the intelligent discrimination which your engineers have shown in selecting for adoption in Japan the methods and processes best adapted to your local conditions. Speaking frankly,

althoug'. you are profuse in acknowledgment of indebtedness to us in America, yet you have probably taken more from Europe, and particularly from Germany, whose conditions certainly approximate more to your own. However, I believe that in the future, as your industries grow to a larger scale, you will take more and more from us—and you will be as welcome to do so in the future as in the past.

In addition to thus adopting foreign methods with rare discrimination, we have observed also in many places abundant evidences of experimenting and research being carried out at your plants, resulting in novel and ingenious improvements on foreign methods. Such is highly gratifying to us, as evidence of originality and power to progress for yourselves along modern lines. Maintain this spirit, and soon you will be teachers yourselves and a source of enlightenment and information to others.

FIG. 47.—HARVEST TIME.

We travel primarily to enlarge our own mental horizon, but, better yet, when we can do it, to be of service to those whom we visit. Fulsome flattery is not the most grateful return for the kindest hospitality, and it is in this spirit that I take the liberty of formulating two questions which I beg you to reflect upon.

First, as the result of some observation of your works and professional staff, I am led to the query: "Are your technical men as keen as they might be in keeping abreast of scientific progress abroad, and are they taking as prominent a part in the great international scientific societies as they should?" I know that such activity presupposes knowledge of the English, German and French languages and much hard study, but our technical men at home find this indispensable. Membership in the large scientific societies puts a man in touch with the world of technical literature as nothing else can do, and opens to him avenues of thought and progress which would otherwise remain closed. To state the case in the con-

crete, for one example, there are at least one hundred mining engineers and metallurgists in Japan who would be greatly benefited professionally by becoming members of the American Institute of Mining Engineers.

Finally, speaking from the standpoint of a university professor, let me ask: "Are there not too few foreigners upon your university faculties?" Twenty years ago foreign professors were numerous in your universities; now there are comparatively few or none. Was not the great intellectual progress of that time largely due to the flood of new ideas thus brought to you, and is the rate of progress being maintained? In America we still get assistance from abroad on our university faculties; we find too much in-breeding deleterious to our best growth. Professor Münsterberg, of Harvard, is an example in point; you will allow me to say that I am an Englishman. What we have found advantageous in our American universities I cannot but commend to you. Keep the intellectual door wide open and your universities will lead Japan in the upward path. Intellectual progress must precede material progress. Take to yourself and use the best intellects you can get, wherever you can get them, and they will be cheap at almost any price.

For all your hospitality and sympathetic comradeship during these few but unforgettable days, we thank you from the bottom of our hearts—*Kokoro Kara arrigato!*

Mr. Otani, President of the Yokohama Chamber of Commerce, who had been the first to welcome us to Japan, now spoke for his fellow-citizens the last greeting in their own tongue. His remarks were translated by Mr. Zumoto:

Mr. Otani happily described himself as the keeper of the "open door" at Yokohama, whose duty it was to welcome the coming and speed the parting guest, and expressed the unanimous desire of his countrymen that the door might be always open. In their name, he wished for us a prosperous homeward voyage, good news from our families upon our arrival, and pleasant memories of our Japanese friends and their country.

President Hunt said that while American hostility to Japan was, as we all believed, a thing impossible, yet he must confess that the American flag had been raised, and permanent American sovereignty asserted, over one piece of land in Japan, and introduced Mr. Thomas Sammons, U. S. Consul-General at Yokohama, as the man who had done the deed.

Consul-General Sammons, in responding, said that Mr. Hunt's allusion gave him a text for some pertinent suggestions. The piece of land referred to had been donated by the Imperial government to the United States, and had been accepted by our government with suitable thanks for what was an act of international courtesy, he believed, without precedent. The land constituted one of the most desirable building sites in Yokohama, and was given in order that the United States might accommodate its growing commerce with Japan by the erection of suitable

consular offices and buildings upon its own ground. Yet, after accepting the gift, our government had taken no steps to make appropriate and adequate use of it. He suggested that the American visitors might properly use their influence at home for the appropriation by Congress of the sum required for these much-needed buildings.

Mr. Sammons, alluding to Mr. Otani's position as the keeper of the open door at Yokohama, said that his own Oriental title as a Consul-General in China had been "the open-door official"—which he deemed a happy translation, since it represented the attitude of American diplomacy in the East.

In conclusion, Mr. Sammons, as an impartial observer, assured the party that, while Japan had evidently made a most favorable impression on them, they, on the other hand, had made a correspondingly favorable impression in Japan, and quoted, amid general applause, the following stanzas from a song written many years ago, in description of a similar tourist company of members and guests of the American Institute of Mining Engineers:

"We're the most delightful party that ever you did see!
We're about as near perfection as it's possible to be!
And the very best of all of it, we candidly confess,
Is that each of us is conscious of his own uncommonness!

"We're beautiful and virtuous; we're witty and we're gay;
We say the very brightest things that any one could say;
But the very best of all of it, we candidly confess,
Is that each of us is conscious of his own uncommonness!"

President Hunt then called upon Dr. R. W. Raymond, Secretary Emeritus of the Institute, to "close the exercises." Dr. Raymond said:

I regard it as a high privilege to speak for my sisters and brethren of the visiting party of the American Institute of Mining Engineers the final parting words.

You have entertained us in a manner far surpassing our utmost expectations. The abundance of your courtesy has been surpassed only by its exquisite grace and artistic ingenuity and variety. At every step you have surprised as well as delighted us. We looked upon you before with admiration and respect, but our admiration has become astonishment, and our friendship, personal affection.

I must be permitted to make special acknowledgment of the favors shown to me during my stay in Tokyo, and particularly of the great honor of the decoration of the Rising Sun, conferred upon me by His Majesty the Emperor of Japan, and of my reception by Her Majesty the Empress. These high distinctions were accorded to me, as the official notification declares, in recognition of my services to the mining industry of Japan. I will not, in excess of modesty, deny that I have been able during the last twenty-five or thirty years to give to Japanese engineers and students in the United States important help. But my individual services would have had little value had they not been reinforced by the

members of this Institute, who cordially responded to my letters of introduction with the open door of knowledge and the open hand of fraternal aid. I wear my honors, therefore, as theirs.

We wish we could present to you, at this hour, some worthy symbol of our appreciation of all that you have done for us. You have laid upon us the obligation of a debt that can never be repaid—that can never be forgotten. And the token of this obligation now offered you is only a token.

This specimen of native crystallized American gold is a small thing, yet it is, like your reception of us, unique, and therefore priceless. Let it indicate our recognition of the native gold of your generous hearts, which has crystallized for us in forms of delicate beauty and enduring strength.

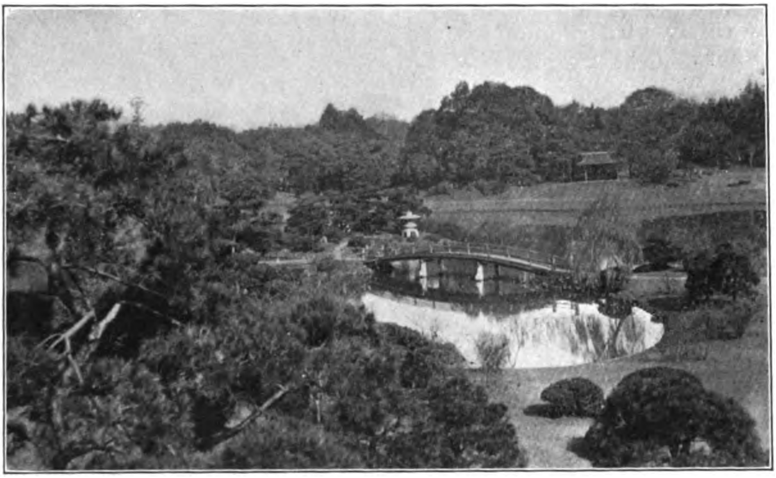


Fig. 48.—Picturesque Japan.

I have carried it in my pocket over sea and land for luck. But the unbroken good fortune which we have experienced here came from no amulet, and we need no such charm on our homeward way to protect us from disaster or disappointment. We shall be guarded by the memory of a happy dream—no, not a dream, but a real sojourn in Paradise!

I deliver this token, therefore, to the Japanese Reception Committee, requesting them to place it in the collection of the Imperial University of Tokyo, with this label: "Presented by Dr. R. W. Raymond, Secretary Emeritus of the American Institute of Mining Engineers, in recognition of the generous and graceful courtesy extended to the visiting party of members and guests of the Institute through the Empire of Japan."

This specimen had been for many years in Dr. Raymond's possession. It is a druse of dodecahedra of native gold, remarkably massive and sharply developed, free from the effects of attrition. It was

found in a gulch in Mariposa county, Cal., and while it contains by weight only about six ounces of gold, its value is enhanced tenfold by its unique character and condition.

At this point in his address Dr. Raymond handed the specimen to Professor Watanaba, who received it for the University with appropriate recognition; after which Dr. R. continued:

And now comes the hardest part of all. My knowledge of the Japanese tongue has been confined to two words, "Ohai O," for friendly greeting, and "Banzai," for enthusiastic praise. It is needless to say that these two words have been on my lips and in my heart continually since I landed on these shores. But to-day I have had to learn another—"Sayonara," farewell—the sad, sweet melody of which lingers like the deep tone of a temple bell. Sayonara! dear old friends, and new that shall be old!

And Sayonara, fair Nippon!

O land of ancient story, long concealed,
In this new age to wondering eyes revealed.

O land of youth renewed, and flag unfurled
To greet the banners of a friendly world!

O land of heroes, strong to do or die,
Yet stronger still for peaceful victory!

O land of templed hills and shadowy bowers,
Of fruitful fields and gardens gay with flowers,
Give us thy love, as we have given thee ours!
Sayonara!

Homeward Bound.

The *Siberia,* Captain Zeeder, lay in the harbor awaiting us; and, as soon as our farewell feast was over, we hurried on board the launches which conveyed us to her. A host of our Japanese friends accompanied us to the ship; rockets soared above us, letting loose balloon-borne flags as they burst in air; banzai and sayonara echoed about us; and with much waving of hats and handkerchiefs we sailed away.

The trip was not like our outward voyage. Many of the original party did not return with the rest, but remained in Japan, or went to Vladivostok, and so on to Europe, by the Trans-Siberian railway, or sailed for China and India. The remainder were pretty thoroughly tired by the strenuous enjoyment of the last eighteen days, and had no heart for organized entertainments, which would be tame, anyhow, after such festive climaxes. Moreover, our record of fair weather was broken by a big storm, which still further disposed many to quiet. The

Siberia took the storm with dignity and poise, and we did not consider it as a very bad one, until the Honolulu newspapers spoke of it as a typhoon—which, by the way, it was not, being, on the contrary, a persistent gale from one quarter, of the kind known to seamen as a "high-glass blow," *i.e.*, a storm characterized throughout by a "high barometer."

Our Chinese crew and stewards had all had their pig-tails cut off, and wore their butchered coiffures with half-embarrassed smiles.

At Honolulu we had a lovely day, Dec. 1. Arriving early in the morning, we were taken in charge by the Hawaiian Engineering Association and conveyed in a government steamer to Pearl Harbor.

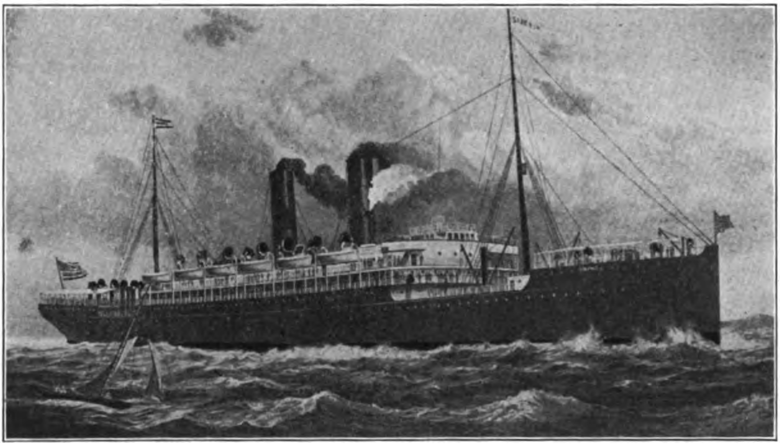


FIG. 49.—S. S. *Siberia*.

The large party receiving and accompanying us on this excursion comprised the following persons: Gov. W. F. Frear, Messrs. B. F., H. G., and W. F. Dillingham of the Hawaiian Dredging Co., which is doing work at Pearl Harbor; Captain Ellicott, U. S. N., of the *Maryland;* Captain Halstead, U. S. N., of the *West Virginia;* Lieutenant Bertholf, U. S. N., of the *Colorado* (these battleships were lying at Honolulu); Civil Engineers of the U. S. N., Messrs. E. R. Gayler, Roy Smith, and C. S. Burrell (in charge of the dry-dock and Pearl Harbor work for the government); F. B. Smith (in charge for contractors); H. M. Hepburn, Vice-Chairman of the Hawaiian Engineering Association and Manager of the Hawaiian Electric Co.; J. E. Sheedy, Secretary of the Hawaiian Engineering Association and Superintending Engineer of the Hawaiian Electric Co.; C. Heidemann, Manager of the Honolulu Iron Works; Professor Gilmore, President

of the College of Hawaii; and many other representatives of Hawaiian industries, including the sugar-plantations.

The party inspected first the dredging of the channel through the coral reef, which prevents other access to the coast, and the large dry-dock in process of erection. They afterwards visited Battery Selfredge, where two 12-in. guns are already in position; and finally they were taken by rail to the Honolulu Sugar Plantation, where they witnessed the whole process of sugar-manufacture, from the cane to the lump.

Returning to Honolulu, they were entertained at a luncheon given by the Engineering Association in the Commercial Club. In the absence of Mr. J. M. Young, Chairman of the Association, Mr. H. M. Hepburn, Vice-Chairman, made a brief address of welcome, to which President Hunt responded.

At 5 p.m. we left the beautiful island in the glory of a gorgeous sunset.

From Honolulu to San Francisco the voyage was uneventful, except for the prevalence, much of the time, of brisk head-winds, which retarded our progress, so that it was the afternoon, instead of the morning, of Thursday, Dec. 7, when we sailed through the Golden Gate, in trembling fear of the San Francisco Custom House!

Badges, Souvenirs, Etc.

The Japanese Reception Committee gave to Acting-President Hunt an ancient Samurai sword, of great value, and to Dr. Struthers a silver cup, a picture of which is given in this report. The latter souvenir, as the donors explained, was given to Dr. Struthers not only as the business manager of the excursion party, but also in recognition of many courtesies shown by him to Japanese engineers both before and after he succeeded Dr. Raymond as Secretary of the Institute.

Dr. Raymond himself, besides the decoration, mentioned on a previous page, which was conferred upon him by the Emperor, received from the forty Japanese members of the Institute a personal testimonial, of which a picture is herewith given, representing in gold, silver, bronze and copper (the leading products of Japanese metallurgy) one of the long-tailed cocks of Tosa, famous as specimens of Japanese skill in the breeding of artificial varieties, both of plants and of birds.

Aside from these and other personal attentions, the members of the party were everywhere the recipients of badges and other souvenirs. The full-page illustration given herewith represents but imperfectly the badges referred to, because it does not reproduce the

artistic color-schemes employed. But it may suffice to show two noticeable features, namely, that of these graceful designs no two were alike, and that all of them combined in some way the Stars and Stripes with the Rising Sun. Many of them were fine examples of the jewelers' art. Besides these, there were souvenirs of other kinds, like the silver memorial medals struck at the Imperial mint of Osaka, and presented to the visitors, or the silver card-cases and cigarette-

FIG. 50.—SILVER VASE, PRESENTED TO DR. JOSEPH STRUTHERS BY THE JAPANESE RECEPTION COMMITTEE.

cases given by the great Takata house to the ladies and gentlemen of the party, and the inexhaustible flood of pictorial postal-cards, albums, etc., with which they were deluged at every stage of their journey.

But, however beautiful and agreeable such graceful exhibitions of courtesy may be, there is one thing which the members of an Institute party value more—namely, such full and accurate information concerning the places and works visited as will satisfy their curiosity at the time and furnish them with the materials of an adequate and accurate recollection. Nothing is more unsatisfactory than to ask questions, or try to hear explanations, in a hurried crowd; and it has been my habit for twenty-eight years to advise the Local Committees of Institute meetings to give us, first of all, clear and comprehensive

FIG. 51.—SACRED COCK AND HEN. BRONZE, GOLD AND SILVER STATUARY GROUP, PRESENTED TO DR. R. W. RAYMOND, SECRETARY EMERITUS, BY THE JAPANESE MEMBERS OF THE INSTITUTE.

FIG. 52.—SOUVENIR BADGES AND MEDALS PRESENTED TO MEMBERS OF THE PARTY DURING THE EXCURSION IN JAPAN.
(See list on opposite page.)

accounts of what we were going to see. Since the arrangements for the Japanese excursion were begun by me, while I was still Secretary of the Institute, I presume that, as usual, I impressed this point upon our Japanese members. At all events, they far surpassed, in this respect, all reasonable demands. At our entrance into Japan, we received from the Reception Committee notebooks, upon which our several names had been printed, and in which we found all manner of useful information; and from that day until we sailed away homeward we were smothered with literature in the English language. comprising guide-books, monographs, maps, statistics, diagrams, government reports, etc., as well as with flags, flowers, electric illuminations, artistic entertainments, banquets and speeches. In both departments of hospitality—the social and the intellectual—our Japanese hosts broke the record. I brought back one piece of baggage more than I took with me, and that was a telescoping case of no small capacity, stuffed with my share of the valuable information freely bestowed upon all members of our party.

Concerning the more private manifestations of hospitality, detailed public acknowledgment would be scarcely permissible, even if it were practicable. Japanese gentlemen do not expect their friends to print descriptions of their home-interiors, family customs and afternoon teas. Suffice it to say, therefore, that many courtesies of this kind were shown to individual guests and groups of guests, and that the little Japanese ladies, in their own homes, as well as in larger social gatherings, bore their part with quiet dignity and charming grace.

Souvenir Medals and Badges.

(See Fig. 52, opposite.)

1. General Reception Committee.
2. Yokohama Chamber of Commerce.
3. Mining Institute of Japan.
4. Imperial Steel-Works.
5. Chiku-ho Coal Mining Association.
6. Fujita Luncheon at Osaka.
7. Sumitomo Smelting-Works.
8. Nikko Smelting-Works.
9. Miike Colliery.
10. Theater Party, Imperial Empire Theater, Tokyo.

POSTSCRIPT

The plan of an excursion to Japan was suggested first in 1909 by Mr. Reiji Kanda, of Tokyo, a member of the Institute who took part in the Spokane meeting of that year, and in the excursions to the National Yellowstone Park, Butte, Anaconda, Cœur d'Alène, Seattle, Tacoma, Salt Lake, and Pueblo, Colo., which preceded and followed that meeting, and during that extended journey won the personal esteem and affection of that party, receiving, at the same time, such an impression of the social and professional benefits of such excursions as made him earnestly desire to have his own country visited in that way. In this desire, he was heartily seconded by Mr. Masayuki Otagawa, a director and consulting engineer of the great Furukawa Co., who had become a member of the Institute in 1904; had spent a considerable period in the United States; and was, to me, as well as to many other members of the Institute, an esteemed friend. The extraordinary enthusiasm with which our visiting party was afterwards received by the government, municipalities, mining and metallurgical companies or firms, educational representatives and private citizens of Japan should not eclipse the fact that these two Japanese members of the Institute kindled the fire which burned so brightly.

This excursion covered more than 12,000 miles of ocean travel, 400 miles of voyage on the Inland Sea of Japan, and 1,500 miles of railroad transportation within the Empire, with innumerable changes and transfers, both of the persons conveyed, and of some 300 pieces of their luggage. It was accomplished without serious mishap to any member of the party, or the loss of any article belonging to it. While the generous and assiduous co-operation of our Japanese friends is worthy of the highest praise, it remains true that the successful handling of the party, in these and other respects, was largely due to the skillful and unwearied labors of its own management, which was in charge of Dr. Struthers and Mr. Vaughan. The preliminary arrangements alone, which lasted ten months or more, were a heavy task. The individual inquiries, stipulations and changes of purpose, on the part of proposed participants in the excursion (some dropping out almost at the last moment); the negotiations with transportation agencies; the communications with the Japanese Committee, either by letter, taking at least six weeks for question and reply, or by expensive and too easily misunderstood cable-dispatch, made the work desperately intense and anxious, and due record should here be made of the satisfactory manner in which all details were arranged for the comfort and convenience of each and every member of the party.

R. W. R.

APPENDIX A.

Visit to the Ashio Mine and Smelting-Works.

A small number of our party made a side-excursion to the Ashio mine and smelter of the Furukawa Co. This is the most productive copper-mine in Japan, though the Besshi and the Kosaka, owned by other concerns, are close competitors; the output of the Ashio in 1910 being reported as 11,843,406 *kin* (1⅓ lb. each), while the Besshi pro-

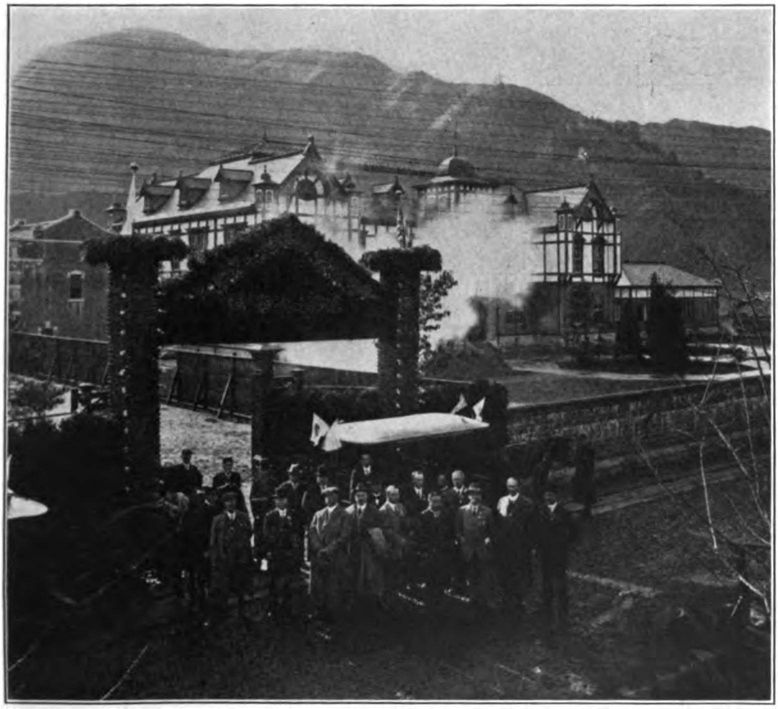


FIG. 53.—"WELCOME" GATE AT OFFICE OF ASHIO COPPER-MINE.

duced 11,131,371, and the Kosako 10,560,501 *kin* The Furukawa Co. owns a large number of copper-mines, three silver-mines and seven coal-mines. The following sketch of the visit to Ashio is kindly furnished by Mr. H. F. Bain, of the *Mining and Scientific Press:*

After viewing the temples at Nikko, one section of the party made the 18-mile trip across the mountains to the Ashio mine, from which comes

FIG. 54.—THE TSUDO MINE, ASHIO.

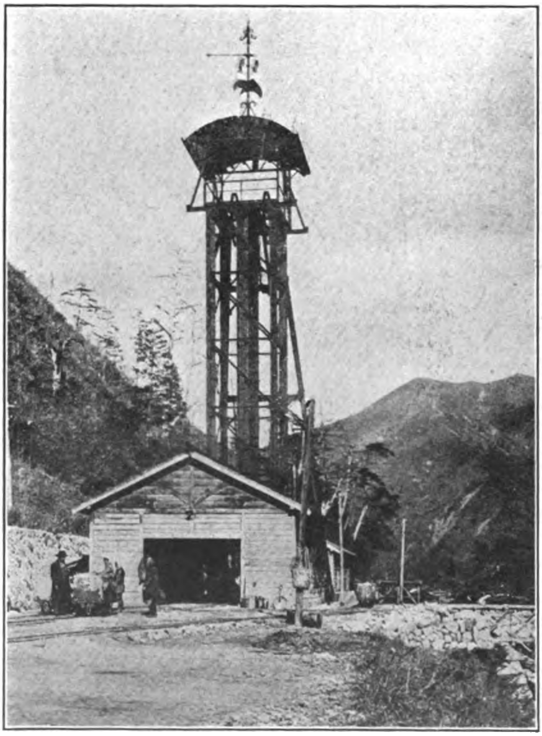


FIG. 55.—HEAD-FRAME OF SHINNASHI SHAFT, ASHIO.

600 of the 1,000 tons of copper used per month at the Nikko refinery. The mine has been described in detail recently by T. T. Read in the *Mining and Scientific Press,* Oct. 14, 1911, so that only a few words will be here devoted to it. The members of the party were taken in 'rikishas first to the Hosoo power house where, after lunch, they were shown the hydro-electric generating-station, which is now being doubled in capacity. A short distance beyond, at the terminus of the wire-rope tramway, saddle horses were waiting for the trip over the pass. Contrary to the general impression regarding Japanese horses, these shaggy beasts were found to be excellent, sure-footed, fast walking and good tempered mountain horses.

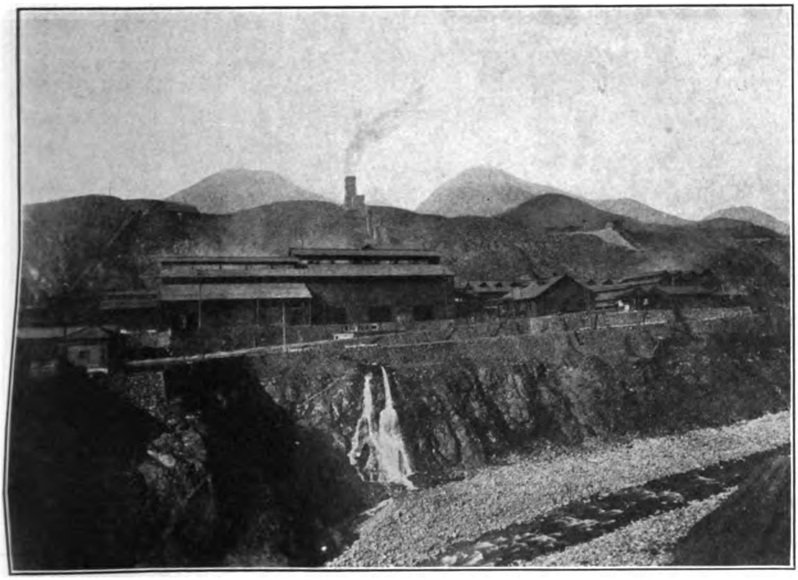


FIG. 56.—THE ASHIO SMELTING-WORKS.

On their backs and along the well-built trail, the three-mile trip proved a delight. At the opposite tramway terminal the party was transferred to diminutive, but gaily decorated narrow-gauge passenger-cars, drawn by horses. In these the five miles to Ashio were comfortably accomplished. Ashio, which is a place of 20,000 inhabitants, was decorated in honor of the visit with miles of Japanese lanterns, and when the cars came into sight a regular bombardment of fireworks, continued at intervals through the evening, was set off. At headquarters an archway, built of the day's run of copper bars and decorated with crossed hammers of electric lights, had been erected. Company and city officials greeted the visitors, who shortly thereafter joined their hosts at a bountiful dinner served at the company club house. The meal was followed by a unique and interesting geisha

entertainment, which was voted by all the guests to be the pleasantest they had enjoyed in Japan. The next morning the visitors were guided through the mines, mills and smelters by K. Inouye, general manager, and his able technical staff. Among features found especially interesting were a briquetting machine of new type, a method of neutralizing acid fumes in blast-furnace gases, a method of preventing freezing in blast-furnaces by feeding coal through the tuyeres, a peculiar double settling-

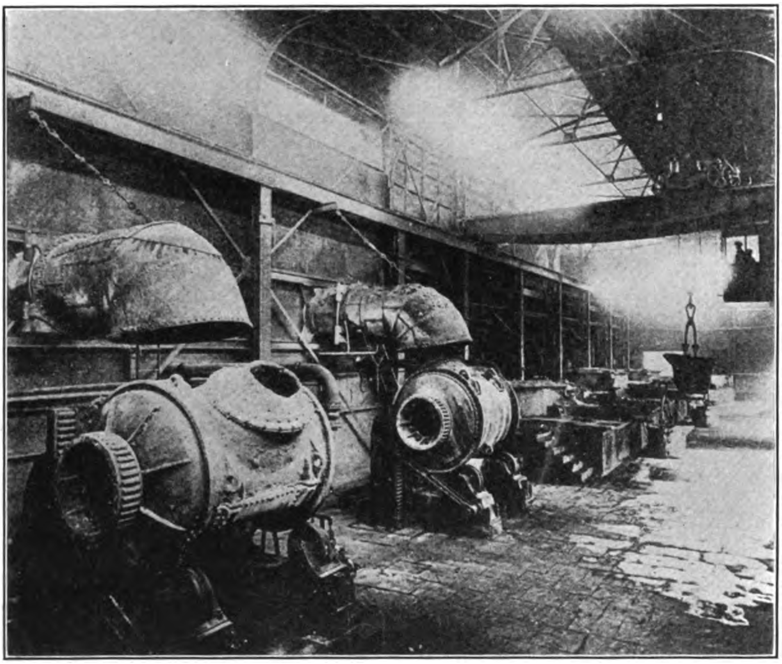


FIG. 57.—COPPER-CONVERTERS, ASHIO SMELTING-WORKS.

cone, the process of pot-roasting, and the new mill, which is under construction. It was evident that the Ashio is not only at present the largest copper-mine in Japan, but that its staff is one of the most progressive anywhere to be found. With all too little time for the inspection of the works, the party returned to Nikko in the afternoon, being guided clear to Tokyo and met at the station there by officers of the Furukawa Co.; another example of the generous hospitality which everywhere met the engineers.

APPENDIX B.

Visit to the Miike Colliery.

The firm of Mitsui consists of eleven partners, each representing one of the eleven Mitsui families. Its operations of banking, mining and commerce are carried on under four organizations, one of which includes the Mitsui Mining Department, having four working collieries (Miike, Tagawa, Yamano, and Hondo), one sulphur-mine (Iwaonobori), one metal-mine (Kamioka—galena and zinc-blende) and many mining concessions for coal, gold, etc., in various parts of the Empire. The total product of coal in Japan was, in 1910, according to the report of the Bureau of Mining Statistics, 13,453,783 metric tons, of which the four Mitsui collieries above named produced 3,258,530 tons, or 24.9 per cent. The Miike colliery, which yielded 1,799,489 tons, is the largest producer in Japan, and the Tagawa colliery of this firm (661,334 tons) comes next.

The Miike mine, with its connected facilities for handling and shipping coal, is doubtless the best example of up-to-date Japanese colliery-engineering. Mr. H. F. Bain, one of those members of the Institute who visited it, Nov. 11 and 12, has kindly furnished the following sketch:

The Miike colliery, visited by one section of the party, belongs to the Mitsui family, which, because of its wealth and age, has been not inaptly characterized as the "Vanderbilt family of Japan." The Mining Department of the Mitsui Gomei Kaisha (Mitsui firm) operates both metal- and coal-mines; and it was to the most famous among the latter that the visitors were taken. The Miike colliery is situated on the Gulf of Ariake in the island of Kyushu. Coal has been known to occur at this point for many years, and was mined a little by native methods, even before the government in 1873 took possession, and under an English engineer opened the first modern pit. In 1889 the property was transferred to the Mitsuis, who made radical and extensive changes, opening new pits in succession, until there are now six working mines, with an average daily output of 6,000 tons. In 1910 the total output of the Miike mines was 1,799,489 metric tons, of which 41 per cent. was exported. The Miike coal has a well established and enviable reputation throughout the Far East, for both its steaming- and its coking-quality. There are eight beds on the concession; but mining is, as yet, confined to the Miike or upper seam. This averages something over 9.5 ft. in thickness, has no clay bands, a hard sandstone roof and a firm fire-clay floor. The coal has been mined for a distance of nearly two miles along the strike, and is open nearly as far down the dip, which is 1 to 10. The deepest shaft, the Manda, which is 41 by 12 ft. in cross-section, is 900 ft. deep. From the bottom the workings extend down the dip to a total depth of 1,132 ft. below sea level. As the overlying material is a soft Tertiary sandstone, the amount of water

to be handled is unusually large. Only in the Pennsylvania anthracite district are there any American collieries where the ratio of water to coal is comparable, and even there it is less. At the Miike mines, 12 tons of water must be raised for each ton of coal won. At the Manda shaft alone, the ratio is 20 to 1, and roughly 1,000 cu. ft. per minute were being pumped on the day we visited the pit. To raise such a quantity of water from such a depth requires large and expensive pumps, and those at the Manda shaft are said to be the largest at any colliery in the world. The most impressive are the 4 Davey Cornish pumps, with compound steam-cylinders, of which the high-pressure is 45 in. in diameter, the low-pressure 90, the water-ram 22 and the stroke 12 ft. The pump has a speed of 8 to 10 strokes per minute, and two of the pumps are held in reserve. In addi-

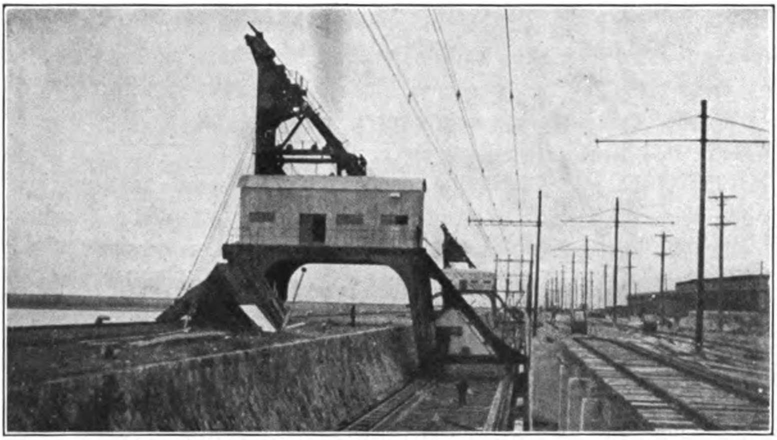


FIG. 58.—MIIKE PATENT COAL-LOADING MACHINES.

tion, there are 5 Janesvilles, each capable of handling 300 cu. ft. per minute against a head of 900 ft., and various smaller pumping engines. The final capacity of the pumps at this shaft is to be 3,000 cu. ft. per minute against 1,000 ft. head. An aggregate of over 16,000 h-p. is used in pumping, but, despite this, less than 10 per cent. of the coal mined is used at the colliery. Coal is also burned to generate steam for many purposes. The amount will be reduced when improvements now under way are completed. At present, coke is made in bee-hive ovens, of which 60 are in operation, burning 300 tons of coal per day and making 180 tons of 48-hour coke. About one-half of the gas is now used. There are now building, however, Coppée ovens; and with the gas from these, two 2,000-kw. gas-engines will be driven to supplement the five 1,000-kw. Curtis steam-turbine generator-sets now in the central power-station.

The coal is worked on a retreating pillar-and-room system; the roadways being 20 ft. wide and spaced at 130-ft. intervals. The coal has an extremely irregular cleavage, and is mined without either powder or shearing. The miners (called "hewers" as in England) pick the coal from

the face with small single-pointed picks, and are paid by the ton, as in America. The coal is forked into cars holding 1,400 lb. and taken to the shaft by means of horses and endless rope. The close cleavage and the system of mining give a large percentage of fine coal, there being 45 per cent. of lump over a 2-in. screen, 10 per cent. of nut, between 2 and ⅞ in., and 45 per cent. under ⅞ in. The lump-coal is sent over a picking-belt, where women take out the slate. Nut-coal is washed; and the fine coal is made into coke.

There are 11,700 mine-workers, of whom 33 per cent. are women. The miners work in 8-hr. shifts; but surface-workers put in 10 hr. Nominally, wages are low, miners getting 35 to 40 cents per day and women coal-pickers about half as much. This, however, does not tell the whole tale.

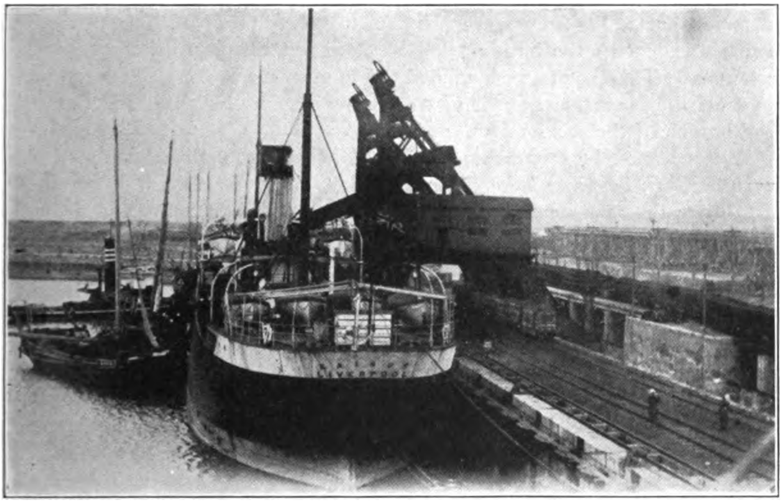


FIG. 59.—LOADING COAL IN MIIKE HARBOR.

For example, house rent is free in some cases, and nearly so in others. Food is sold at cost or below. For rice, the staple food, the price is fixed; varying only with the term of service of the employee. Miners who have been with the company for five years are now buying their rice at about one-third what it costs the company in open market. There is a charge of 7½ cents per month for sanitary service; but boiled drinking-water is furnished to all miners' houses. Schools, hospitals, a day-nursery for children, sick-benefits, accident- and death-benefits and amusements are all provided by the company; and, to serve miscellaneous wants, a store is maintained, with prices so regulated that in three years the total profit was less than $8. This is not the American way of doing things, but quite accords with the Japanese notion of regarding a business as a family enterprise and the employees as members of the family.

The yield of coal per miner is about 2 tons per day, or 1 ton per day

per employee. A larger supervising staff is employed than in the United States, there being 40 bosses for 2,200 men. All the work about the shaft, and indeed the whole property, has been excellently designed and executed. A particularly commendable feature is the permanent character of the work—steel tipples, brick stations and stables, heavy rails underground, set on large ties and with rock ballast. When it is remembered that a modern colliery lasts 40 to 50 years and often longer, the real economy of such features, coupled with retreating mining, is apparent. That in a country of high interest charges such as Japan, the directors should go to expense in this direction, is especially striking.

The technical work at the mine is under the direction of a skilled force of engineers, graduates of the Imperial University at Tokyo. Among those at the mine may be mentioned Messrs. H. Uyeki, vice-manager of mines; J. Fujioka, mining engineer; T. Tomita, superintendent at the Manda shaft; T. Takasu, superintendent of transportation; D. Kurita, superintendent of the harbor; and K. Akabane, manager of the sales department. The visitors were guided to the property by Mr. Y. Ogita, manager of the Nagasaki branch of the Mitsui Bussan Kaisha, Ltd., the selling branch of the Mitsui firm.

A word must be said about the Miike harbor, though no complete description can be given here. The rise and fall of the tide at Miike is 18 ft., hence the new inner harbor, having an area of 32 acres and a depth of 28 ft., is closed by a tidal lock, to which a passage, 300 ft. between breakwaters, leads from the sea. Within the harbor there is room for three ships to load coal, and one merchandise, at the same time. The coal is brought to the dock over a private railway in 8-ton hopper-bottom cars. These may deliver to storage; but when ships are coaling they dump direct into skips, which, by means of the Miike patent loader, are drawn up an inclined track to whatever may be the proper height for dumping, through a spout, into the ship's hold. The peculiarity of the loader is a telescopic rail, which permits the skip to be stopped and dumped at any point. A car per minute can be handled; and the capacity of each of the three loaders is 5,000 tons per day. The loader was invented by Mr. Takuma Dan, the earliest Japanese member of the Institute, a member of the general Reception Committee and one of the ablest engineers in Japan. He also designed much of the other machinery used at this mine. Last year 373 vessels were loaded, over one per day.

APPENDIX C.

The Sumitomo Mines and Works.

The brief allusion in the foregoing narrative to the visit of our party at the Sumitomo Smelting-Works, on the island of Shisaka, in the Inland sea, does not adequately describe the nature and operations of this company. Like other great business enterprises in Japan, it has been developed from the enterprises of a single family. The house of Sumitomo has been known in Japanese mining since the seventeenth century. From its general office in Osaka, it controls operations in mining, banking, warehousing, and the manufacture of copper, steel and cables, through Baron Sumitomo, the present head of the house, who is assisted by a Director in each department.

The Besshi copper-mine, owned by this house, and situated about 12½ miles from the sea, on the island of Shikoka, is one of the most important producers of copper in Japan. It is mainly a deposit of cupriferous pyrite, carrying about 4 per cent. of copper, 5,000 ft. long, from 2 to 25 ft. wide, and developed at present to about 2,000 ft. (maximum) from the outcrop. There are 10 levels (43,000 ft. in aggregate length), and an incline 1,782 ft. long, besides other mine-workings. The mine-water, being heavily charged with acids and salts injurious to agriculture, is conveyed (after precipitation of most of its copper) through a 9.5-mile channel to the sea. The ore is sent to the smelting-works at Shisaka Island (visited by our party Nov. 9), where both the old process of roasting and smelting and the newer pyritic smelting are in use, together with other modern improvements. The refined copper ranges from 99.7 to 99.9 in purity, and commands a specially high price in foreign markets. The mine produces more than 200,000 tons of ore annually, and the annual output of refined copper exceeds 6,500 tons.

The motive power has been chiefly electric, and generated by steam; but a hydro-electric 3,000 kw. installation is about completed. The fall is 1,975 ft., and the water available about 25 cu. ft. per second. For transportation, the firm employs a private railway 6 miles long, an aerial tramway 12,276 ft. long and a fleet of 80 sailing-vessels, one tug and three steamships. Some 2,300 men are employed in the mining, and 1,400 in the metallurgical department; and arrangements for sanitation, education and recreation are provided by the company free of charge.

This house operates also a large colliery (over 300,000 tons annually) at Tadakuma, and works at Osaka for the manufacture of sheets, rods, bars and wires of copper, as well as a steel-casting establishment, etc., etc.

APPENDIX D.

The Imperial Steel-Works at Yawata.

These works, established by the government, began operations in 1901 for the purpose of supplying about 60,000 metric tons, or one-half of the annual demand at that time for iron and steel in Japan. That demand has greatly increased during the last ten years, and at the present time amounts to about 700,000 tons, of which the works at Yawata produce 150,000, and private establishments at other places about 50,000 tons, leaving 500,000 tons to be supplied by importation, of which England furnished in 1909 about 52 per cent., Germany over 20 per cent., and America, Belgium, France and China (in the order named) the remaining 28 per cent.

The Imperial Steel-Works were maintained at great cost of installation and an annual loss in operation of from $500,000 to $750,000, until 1910, in which year they realized a profit of $50,000. The causes of loss are said to have been the high price of coal, the insufficient supply of domestic pig-iron and iron-ore, and the lack of skilled labor. In spite of these adverse economic conditions, the works have been maintained by the government for reasons of national policy, though the annual discussion of the subject in Parliament has developed considerable opposition. I am indebted for this general statement to an article by Mr. T. Haga, in the *Mining and Scientific Press* of Feb. 18, 1911. In the same journal, Dec. 16, 1911, Mr. H. Foster Bain, a member of our party, gave a description of these works, from which the following is taken:

"The output is not large, there being only three blast-furnaces, each with an average capacity of 150 tons of pig per day and a maximum of 200. An additional stack is now being built. Both Bessemer and open-hearth steel is made, as are plates, wire, bars, rails, structural steel, projectiles, and a wide variety of products. The problem of steel-making in Japan is not unlike that on the Pacific Coast: there is a demand for many different things, but not enough for any one kind to keep a large plant busy. In 1910 the total steel manufactured in Japan, with over 46,000,000 population, was 79,676 metric tons. In addition, 425,758 tons was imported. Private works in Hokkaido, operated by English and Japanese in partnership, and the Sumitomo works at Osaka, furnish local competition to the Imperial Works in certain lines. The latter, however, must make an effort to satisfy, as far as possible, the national needs in other lines. As a result the plant is unusually complex. There are a great many small plants in the works, and the visitor can see at the same time an unusually large number of distinct processes under way. The ore used comes from China, Korea, and Japan in about the proportions of 50 to 40 to 10. The Chinese ore is from the Ta-yeh mines, near Hankow, and is of high grade, analyzing up to 64 per cent. Fe. The Korean ore is lower, 52 to 54 per cent., and the local ore still leaner. Some 50 to 52 per cent. ore is brought from Hokkaido. The coke is made at the works in Semet-Solvay ovens, the coal being 20 per cent. Miike, and 80 per cent. local washed coal. The Miike coal is strongly coking, the local coal is not, but the mixture gives a satisfactory product at reasonable cost. About 1,000 tons of coal per day is

used to produce 600 tons of coke. The ratio of pig to coke is 1 to 1.2. As the flux used is magnesian, the slag is not available for making cement, but instead is granulated and made into building brick. In general, the works are well kept and well run. The furnaces and converters are not driven as fast as is usual in the United States and have therefore a relatively low capacity. But the quality of the products throughout is excellent. The works were able to show a profit for the first time in 1910, when there was a surplus of $50,000. It should be remembered, though, that the loss on manufacturing in other years was more than balanced by the lower price of steel products, besides which the works accomplish the main purpose, that of giving the Empire an independent source of supply. The works are under the direction of Lieutenant General Baron Yujiro Nakamura, assisted by a large staff of engineers."

APPENDIX E.

The following brief description of the various cities visited is taken bodily from the excellent pocket diary prepared by the Japanese Reception Committee and given to each member of the party.

Yokohama.

YOKOHAMA, the first landing place of tourists from across the Pacific, is a city of 394,000 inhabitants, of whom about 2,000 are Occidentals—Americans about 400, British about 900. It is one of the two foremost open ports of Japan, the other being Kobe. It was a mere mud flat with a few fishing-huts when Commodore Perry anchored near it in 1854. Its growth and prosperity are due to its foreign trade. Being a modern town it can boast of only a few famous sights: NOGEYAMA, a hillock behind the railway station, contained several popular Shinto and Buddhist shrines, and commands a general view of the city and of the bay. HONMOKU (2 m.) is a sea-bathing resort. NEGISHI (2 m.) has a famous race-course, usually attended by the Emperor's representative, and commands a fine view of Mississippi bay where Perry landed.

In Yokohama are found the Consulates of all the Treaty Powers, the Prefectural Governor's Office, and the branches or agencies of large banks, both foreign and Japanese.

CONSULATES:—

American, No. 234; British, No. 172; German, No. 81; French. No. 84.

CHURCHES:—

Christ Church (Anglican), No. 235, Bluff; Union Church (Protestant), No. 157, Bluff; Roman Catholic Church, No. 80.

BANKS:—

Hongkong and Shanghai Bank, No. 2; Chartered Bank of India, Australia and China, No. 58; The Yokohama Specie Bank, Minami-Naka-dori Gochome; National Bank of China, No. 75. etc.

Tokyo.

TOKYO was made the capital of Japan, and its name changed from Yedo, in 1869. It has 2,186,079 inhabitants (1908), and comprises in area something like 28 sq. miles. It is the political and administrative center of the Empire. Here resides the Emperor and here also are all the great offices of state. Nearly all the great nobles and most of the wealthy magnates live in the capital. Here are found also all the great banks—the Nippon Ginko, Japan Industrial Bank, Japan Hypothec Bank, Daichi Ginko, Mitsu Bishi Ginko, Mitsui Ginko, Dai Hyaku Ginko, Yasuda Ginko, and others.

Tokyo is now in a transitional stage. From a great feudal capital of forty years ago—with the Castle (now the Imperial Palace) as the center, the large residences of the Daimyos surrounding it and the narrow, crowded streets of the business quarters—it is now being transformed into a modern and cosmopolitan city. Most of the important streets have been recently enlarged and remodeled, but the transformation process is by no means complete.

As seen from any height, Tokyo presents a semi-rural aspect, owing to the abundance of trees and foliage and lack of tall buildings. In spring when the cherry-trees blossom the whole city is transformed into a veritable garden of bloom.

The city was founded by Tokugawa Iyeyasu, the great founder of the Tokugawa Shogunate, in 1603. For 285 years (till the fall of the Shogunate in 1868) it remained the *de facto* political capital of Japan. After the Restoration (1868) the Emperor took up his abode in Yedo, at the same time changing its name to Tokyo, which means the Eastern Capital.

The most important thoroughfare in the city is the one leading from the Shimbashi station to Uyeno. The part between the station and Meganebashi (Ginza-dori and Nihonbashi-dori) particularly is worth seeing. Near the Nihonbashi (Japan Bridge) is the famous Mitsukoshi department store, which every traveler ought to visit.

Principal Sights.

The IMPERIAL PALACE, generally called Kyûjô, where the Emperor and Empress reside, occupies the very center of the city. The Palace stands on the site of the old castle of the Shoguns, which was destroyed by fire in 1873, and the present palace was built in 1889. It is not accessible to the public. Nijubashi, or the two-fold bridge, is the entrance where those favored with an imperial audience are admitted. The Emperor gives audience in Phoenix Hall, and the Empress in Kiri or Paulownia Hall. The Palace buildings are of choice wood and in the best Japanese style, but are so arranged as to suit the ceremonies that are conducted largely in foreign style. The decorations, in which foreign methods have been adopted in endless ways, are simple and severe in taste. The ordinary brick-and-plaster buildings to be seen from the east side, rising behind the moat, contain the offices of the Imperial Household Department. The old plastered turrets, the remnants of the old castle, may still be seen here and there on the outskirts of the palace inclosure. The whole is inclosed by deep moats. On the east side of the Palace, in front of the Nijubashi is a park planted with pine-trees, in whose midst stands an equestrian statue of

Kusunoki Masashige, a great captain and model hero in the Imperial cause (14th century).

HIBIYA PARK, a new public garden, where flowers are found nearly all the year round, is near the Palace and is separated from it only by a moat. On the east side of Hibiya is found the Daijingu, a branch of the Great Shrine in Ise. Here it is quite a fashion to have marriage rites performed according to ancient national custom. Opposite the Daijingu is the Imperial Hotel, and right behind the hotel, the Nobles' Club, and next to the latter the Japan Hypothec Bank. On the south side of the Park are the Houses of the Diet, which are temporary wooden structures. On the west side, are the Navy Department, the Supreme Court and Department of Justice, all somewhat imposing brick buildings, while opposite the Navy Department across the street is the Foreign Department.

SHIBA PARK, within a short distance of Hibiya Park, contains the famous Buddhist temple, Zôjôji, of the Jodo sect; and within its inclosure are found six splendid mausoleums of the Tokugawa Shoguns. Of the fifteen Shoguns, the last, Keiki, who abdicated, is still living, while the two most famous, Iyeyasu and Iyemitsu, lie buried in Nikko, six others at Uyeno, at the opposite end of Tokyo, and the rest at Shiba. These mausoleums and mortuary shrines are counted among the chief marvels of Japanese art—in carving, painting, gilding and lacquering as second only to the Nikko temples.

THE TOMBS OF THE FORTY-SEVEN RONINS, are found at Sengakuji, south of and near Shiba Park. The popular reverence for these faithful retainers (who revenged the death by *harakiri* of their Lord, Asano Takuminokami, by killing Kira Kozukenosuke, who caused his death) is attested by the incense perpetually kept burning before their graves.

THE KOYOKWAN, or Maple Club, situated on a hill behind the Shiba Park, is a well-known restaurant where excellent dinners (Japanese style) and beautiful dances are given.

North of the Palace across the outer moat is found the YASUKUNI-JINSHA, a temple dedicated to the soldiers who sacrificed their lives in the Imperial cause in the wars since the Restoration (1868). A bronze statue of General Omura Masujiro, who laid the foundation of the present military system of Japan, stands in a wide compound in front of the large bronze *torii* (gateway to the temple).

YUSHUKAN, within the temple compound, contains many fine specimens of Japanese swords, armor, trophies of the Chino-Japanese and Russo-Japanese wars, etc.

THE KOISHIKAWA ARSENAL (Hôhei-kôshô) occupies the site of the former residence of the Lord of Mito. The garden, Kôrakuen, still remains intact, and is considered one of the finest specimens of Japanese landscape gardening.

THE KOISHIKAWA BOTANICAL GARDEN (Shokubutsu-en), kept up under the auspices of the Tokyo Imperial University, is open to the public.

THE TOKYO IMPERIAL UNIVERSITY (Teikoku Daigaku), oldest and most complete of the modern universities of Japan, stands at Hongodai, not far from the Arsenal and the Botanical Garden, and has many substantial brick buildings. The University comprises Colleges of Literature, Law, Medi-

cine, Science, Engineering and Agriculture, the last being in the western outskirts of the city.

UYENO PARK, famous for its cherry-blossoms in Spring, lotus flowers in Summer, and also for the Shoguns' mausoleums, is the most popular resort in the metropolis. It is conspicuous for its temples and large trees, and is as old as the founding of the city.

Uyeno, lying due northeast of the castle, was regarded according to popular superstition as the "demon's gate," and an unlucky quarter. Hence, to ward off evil influences, splendid Buddhist temples were erected. The Shogunate government adopted the custom of inviting a member of the Imperial family from Kyoto as the chief abbot of these temples, with the secret design of setting him up as a rival Emperor, in case of necessity.

The Park contains Tôshogû, a beautiful temple dedicated to Iyeyasu, the founder of the Tokugawa family, a Zoological Garden, the Imperial Library, the Imperial Museum, and a well-known hotel and restaurant, Seiyo-ken. The library and museum are the most extensive and best equipped of the kind in Japan; this latter especially is worth a careful inspection.

ASAKUSA KWANNON, dedicated to Kwannon, the Goddess of Mercy, and situated in the northeast outskirts of the city, is a most popular temple; and its surrounding grounds, with cheap shows and theatricals, are a great holiday resort of the middle and lower classes. Here "nothing is more striking than the juxtaposition of pity and pleasure, of gorgeous altars and grotesque *ex-votos,* of dainty costumes and dingy idols, the clatter of the clogs, cocks and hens and pigeons strutting about among the worshipers, children playing, soldiers smoking, believers chaffering with dealers of charms, ancient art, modern advertisements—in fine, a spectacle than which nothing more motley was ever witnessed within the precincts of a religious edifice."

MUKOJIMA, a part of the left bank opposite Asakusa of the river Sumida, which cuts the city into unequal portions, is celebrated for its avenue of cherry-trees. In April, for about a week, it is densely crowded with pleasure-seekers, and the tea houses on the embankment and pleasure boats on the river present a busy scene of music and gayety.

THEATERS:—

Teikoku Gekijo (Imperial Theater), near Hibiya Park, a new building in European style;

Kabukiza, at Kobikicho;

Meijiza, at Hisamatsu-cho;

Kokugikan, near the Ryogoku bridge, is famous for wrestling matches "sumo," which are held in January and May.

CHURCHES:—

Church of England in Shiba, Sakaecho; American Episcopal, Union Church, Roman Catholic, all in Tsukiji; Greek Catholic Cathedral, in Surugadai.

Nikko.

NIKKO, 91 miles from Tokyo, reached by rail in five hours, is justly famous for its beautiful temples—chapels and oratories—connected with

the tombs of Iyeyasu, the great founder of the Tokugawa family, and his celebrated grandson, under whom the Tokugawa Shogunate was finally established on a secure basis. As was mentioned in connection with the Shiba temples, of the remaining Shoguns some are buried in Shiba and some in Uyeno. These temples are set in the midst of exquisitely beautiful natural scenery, nature and art combining to heighten its charm. The temple compounds are entered after passing the Karibashi (or the Temporary Bridge), spanning the river Daiya, about forty yards below the famous red bridge—the Mihashi—which is now closed.

THE MIHASHI is a sacred bridge, which was formerly opened only on the occasion of a visit of the Shogun.

MAUSOLEUM OF IYEYASU is reached through the world-famed Yômei-mon, called also Higurashi-mon ("spending-the-whole-day gate"), meaning that visitors get so charmed with the exquisitely beautiful decorations of the gate that they linger at the spot for the whole day. The oratory, the chapel, storehouses, the bell-tower, the drum-tower, etc., are all decorated with arabesque carvings in wood of animals, plants and other objects.

MAUSOLEUM OF IYEMITSU is similarly fitted up with gates, oratory and chapel, which are only slightly less elaborate than those of the tomb of Iyeyasu.

CHUZENJI is a lake high up the hill (4,400 feet above the sea), eight miles from Nikko (jinrikisha, kago, or saddle horse may be hired). The lake is seven and a half miles east and west, two and a half miles north and south, being twenty miles in circumference. The water is clear and deep, abounding with salmon, trout, carp and other fish. On the lake side are found summer villas of foreign residents of Tokyo or Yokohama.

THE NIKKO COPPER-WORKS, owned by the Furukawa Mining Co., is reached by electric tramway (five miles). THE ASHIO COPPER-MINE, also owned by the same company, is eighteen miles from Nikko.

Kamakura.

KAMAKURA, one and a half hours' railway ride from Tokyo, is a seaside resort with many villas. It was the site of the capital of Japan between 1192 and 1333, under the Shogun of the Minamoto family and the Hojo Regents. The place contained in the days of its prosperity a large population (said to be 1,000,000). It is now chiefly interesting for its historical remains and associations.

THE TEMPLE OF HACHIMAN, where is worshiped the Emperor Ojin, who on his death was deified as the God of War, stands on a hill called Tsuruga-oka, facing the sea, and is approached by a stately avenue of tall pines leading from the shore. After passing through three stone *torii,* one ascends a broad flight of stone steps. Notice the famous *icho* tree (Gingko, or *Salisburia biloba*), said to be 1,000 years old. The present temple was rebuilt in 1828, after it was destroyed by fire.

THE DAIBUTSU, or Great Buddha, is in Hase, a part of Kamakura. It gives, as nothing else does, an impression of the spiritual majesty and peace which comes of perfect knowledge of the truth. The Daibutsu is 49 feet 7 inches in height and 97 feet 2 inches in circumference. The

eyes are of pure gold, and the silver boss weighs thirty pounds. The hollow interior contains a shrine, and a ladder leads up into the head.

THE TEMPLE OF KWANNON, popularly known as Hase-no-Kwannon, stands on a hillock, near the Daibutsu. This famous image of the Goddess of Mercy stands behind folding-doors, which will be opened by a priest on the payment of a small fee. By the dim light of candles the figure is but indistinctly seen. It is of brown lacquer, gilded over, and is 30 feet 5½ inches high.

Enoshima.

ENOSHIMA is a picturesque islet, or, more properly, a small peninsula (only at full tide is it surrounded by the sea), covered with luxuriant forests, in the midst of which are several temples. On the ocean side is a cave dedicated to the Goddess Benten, the guardian deity of the island. There are several large inns, which are holiday resorts of people from Tokyo and Yokohama.

Hakone.

MIYANOSHITA, in Hakone, is reached by rail from Tokyo to Kodzu (two hours and forty-five minutes); thence by electric tram to Yumoto (one hour); thence by jinrikisha or on foot three and three-quarters miles up the hilly path along the Hayakawa to Miyanoshita (one hour by jinrikisha, one and a quarter hours on foot). Hakone is the general name of the mountainous district at the neck of the peninsula of Izu. It is famous for many hot springs which attract numerous visitors from all parts of the country at all seasons, but especially in summer, when the region, being several thousand feet above the sea level, is cool and refreshing. Miyanoshita is the best known of these hot springs, particularly among foreigners. The Hotel Fujiya, in European style, has excellent accommodation. The pure air, beautiful scenery, charming walks and delicious hot baths always attract a large number of foreign visitors.

Kyoto.

KYOTO is 328 miles from Tokyo, by rail thirteen and a half hours; from Osaka twenty-seven miles, or fifty minutes; from Kobe forty-seven miles, or one hour and forty minutes. It was founded in 794 A. D., by the Emperor Kwammu, and remained the seat of the Imperial family and the capital *de jure* of the Empire till 1868, although for a large part of the time the *de facto* administration of the country was centered either in Kamakura or Yedo (now Tokyo). The city is most beautifully situated, being bordered on three sides by well-wooded hills, and open on the south side, where flows the river Yodo, which was an important means of communication with Osaka before the opening of the railways. The city is unequally intersected north and south by the Kamogawa, the main part lying west of the river. The streets are laid out very regularly, a rare thing for so old a city. It is famous for its fine embroideries, silks and velvets, and porcelain, bronze and cloisonné wares. It is noted also for its fine temples and ancient palaces (878 Buddhist and 82 Shinto temples). Though no longer the *de jure* nor the *de facto* capital of the Empire, it

still remains the classical and the fine art metropolis of the country. The city has about 380,000 inhabitants.

THE OLD IMPERIAL PALACE, the Gosho, former residence of the Mikados, consists of several large buildings, and is inclosed by tall tile-roofed mud walls, plastered on the surface, rectangular in shape and pierced by six gates. The visitors, admitted only by special permission granted by the Imperial Household Department, are first shown into an ante-chamber, formerly used as a waiting-room for Daimyôs; then led into the Seiyô-den, a suite of several large apartments, used on the occasion of *levées* and Shinto festivals; then into the Shishin-den, a large hall used for coronation ceremonies, for the New Year's audience and so on. A corridor leads from the Shishin-den to the Kogosho, or minor palace; another long gallery leads to Ogakumonjo, or the Imperial Study; and besides these there are the Tsune Goten, or the usual residence of the Mikados; the Goza-no-ma, or the Imperial sitting-rooms; the On-mi-ma, or the August Three Rooms, where private audiences were formerly granted.

THE DOSHISHA, situated next and north of the Palace, is the Christian University founded by the late Rev. J. H. Neeshima, under the auspices of the American Board Mission.

KINKAKUJI, or "Golden Pavilion," a part of the Palace, was built by Shogun Ashikaga Yoshimitsu in 1397, to serve as a retreat from the world. All the palace buildings have disappeared except this three-storied pavilion, which is much dimmed by age, most of the gilding being worn off. It stands on the edge of a pond and in the midst of an exquisite landscape garden.

THE NIJO PALACE, formerly the castle belonging to the Tokugawa Shoguns, was built by Iyeyasu in 1603. The halls and apartments are most splendidly and gorgeously decorated ("a dream of golden beauty"), the paintings on the sliding screens being the work of some of the greatest artists. Admittance can be had only by the special permission of the Imperial Household Department.

CHION-IN, a great Buddhist temple, the headquarters of the Jôdo sect. There is here a famous gigantic bell which is 10.8 feet in height, 9 feet in diameter and 9½ inches in thickness, weighing 100,000 pounds.

MARUYAMA PARK has a number of well-known restaurants, among them the Nakamuraro, and so on.

YASAKA-JINSHA, or the Gion temple, is a popular shrine (mixed Shinto and Buddhist). Near the Gion temple, at Hanami-koji, is given in April for twenty nights, a fascinating kind of ballet dance called Miyako-odori.

KIYOMIZU-DERA is a large temple of Kwannon, or the Goddess of Mercy, dating back to the eighth century. The famous potteries, the Kiyomizu, are made and sold in the neighborhood.

TOYOKUNI-JINSHA is a shrine dedicated to Toyotomi Hideyoshi, or the Taiko, one of Japan's greatest statesmen and warriors, who lived in the sixteenth century. The shrine stands on a hill, Amidamine, near the actual burial place of the hero.

SANJU-SANGEN-DO, a large temple 398 feet long and 57 feet wide, contains 33,333 images of Kwannon, the Goddess of Mercy.

THE IMPERIAL MUSEUM (or Teikoku Kyoto Hakubutsukwan) contains

numerous Buddhist images and statues, besides ancient lacquer and embroidery, porcelain, coins, armor, recent war trophies, Imperial robes, palanquins, *Kakemono,* manuscripts, and so.

GINKAKUJI, or Silver Pavilion, is a summer palace built in 1479 by Ashikaga Yoshimasa, after his retirement from the Shogunate. The Silver Pavilion was built in imitation of Kinkakuji (Golden Pavilion), previously built by Shogun Yoshimitsu. Here was built for the first time in history a tea ceremonial room.

NISHIJIN is a district, in the northwestern corner of the city, where various silk fabrics known as "Nishijin-ori" are manufactured.

KITANO-NO-TENJIN, in the neighborhood of Nishijin, is a temple dedicated to Sugawarano-Michizane, a celebrated scholar and courtier of the tenth century.

NISHI HONGANJI, or the Western Branch of the great Monto Sect of Buddhism, or the Honganji, was founded in the thirteenth century. The temple building, with exquisitely adorned apartments, is well worth visiting.

HIGASHI HONGANJI, or the Eastern Branch of the Monto Sect of Buddhism, is a rival sub-sect, having the same doctrine and cult as the Western Branch. The temple buildings are new, having been rebuilt in 1895, after being destroyed by fire.

In Kyoto are several Government institutions of learning, such as the Kyoto Imperial University, the Higher School (a college course preparatory for the University), the Higher Polytechnic Institute, and so on.

In the neighborhood are found several interesting sights well worth visiting, viz.: the Rapids of the Hozugawa, a day's trip down the rapids from Kameoka, a town eleven miles distant (fifty minutes by train); Miidera, romantically situated, commanding a fine view of Lake Biwa, can be reached by jinrikisha (about seven miles) or by train for the greater part of the way from Kyoto.

Nara.

NARA, twenty-five miles by train from Kyoto, was an ancient capital of Japan, from A. D. 709 to 789, during seven reigns, before the removal of the seat of government to the neighboring province of Yamashiro (being finally fixed at Kyoto) by the Emperor Kwammu. The eighth century in Japan was the time when Chinese Buddhism and civilization—particularly architecture—poured in at flood tide, and Nara, which must have been then ten times larger than at present, with palaces, temples, gardens and walks, was the center of this new civilization. All the natural beauty of the place remains unchanged, but of the proud works of man only a very small part of their former glory can be seen to-day.

KASUGA-NO-MIYA, founded in 767 A. D., is dedicated to the ancestor of the Fujiwara family, a powerful clan which held the reins of power at the Court for 1,000 years. A few young girls—priestesses—are in attendance at the temple to perform the ancient religious dance called *Kagura,* at the request (and on the payment of a small fee) of the worshipers. On the background is a classic hill, the Mikasano-Yama, and the temple is surrounded by tall cryptomerias, in the midst of which tame

deer roam, expecting to be fed by worshipers. The temple is approached through an avenue lined by about 3,000 metal or stone lanterns or "tôro" (ishi-doro).

NIGATSUDO, founded in 753 A. D., is dedicated to Kwannon, or the Goddess of Mercy.

TODAIJI, founded in 728 A. D., is a temple where is found the colossal statue of Buddha, "Nara-no-Daibutsu," which, though inferior to the Daibutsu at Kamakura in workmanship, is much larger, being in fact the largest of its kind in the world. The image was completed in 746 A. D., and its dimensions are as follows:

	Feet.	Inches.
Height	53	6
Length of face	16	—
Breadth	9	6
Diameter of each nostril	3	—
Length of fingers	4	3/4
Circumference of the lotos flower	69	—

HORYUJI, on the southwest suburb of Nara, was built in 607 A. D., by Shôtokutaishi, a crown prince devoted to the cause of Buddhism, is of wood, as nearly all the ancient buildings were, and to-day is the oldest structure in Japan. It is still in a fine state of preservation, considering its age. The temple is not only in itself an interesting object of study as a specimen of the ancient art of China, but here is preserved an enormous amount of all manner of relics and antiquities.

Osaka.

OSAKA, with 1,000,000 inhabitants, is the commercial metropolis of Japan. The city covers an area of more than eight square miles, is intersected from east to west by the river Yodo, and also by numerous canals, which are crossed by hundreds of bridges. According to tradition, the city is situated on the site of an ancient capital under the Emperor Nintoku in the fourth century, but its actual founder was the great Taiko, or Toyotomi Hideyoshi, who ruled Japan as the Regent in the sixteenth century. Osaka is to-day a great manufacturing and commercial center—particularly in regard to trade with China. Though its harbor works have been practically completed, the actual foreign trade is still conducted through Kobe.

Osaka can boast of but few famous temples or other works of art. Its chief sight is the Castle. This was built by the Taiko, Hideyoshi, in 1583, and was probably the grandest of its kind. It was burned in 1868, at the close of the Tokugawa Shogunate, and only two portions of its foundations remain to tell the tale of its past glory. The place is now occupied by the barracks and headquarters of the Fourth Army Division. The great inner moats, paved throughout with granite, and the huge stones (some forty by sixteen feet) used as foundations may still be seen. These stones, the contributions of different vassal Daimyos, were brought from great distances.

ZOHEIKYOKU, or the Mint, is where all coins are made in this country. It was established in 1871, under English directions.

TENNOJI TEMPLE, founded in A. D. 600 by Prince Shôtoku-taishi, is celebrated for its five-storied pagoda. Imamiya-Koyen, or the extensive space intended for a public park, lies close to the temple.

The great interest of Osaka centers in its business and industrial activities. No other city in Japan possesses so many chimneys as Osaka, while its narrow streets, such as Shinsaibashi-suji, are lined with stores, small in size, but well stocked with goods and ware. The river is also its glory. In summer evenings the scene here is of the gayest description. "Hundreds of boats float lazily on the water, filled with citizens, who resort hither to enjoy the cool river breezes, while itinerant musicians, vendors of refreshments and fireworks, etc., play amongst the merry throng, doing a thriving business."

DOTONBORI, in the south part of the city, where are found shows and theaters, restaurants and all sorts of pleasure resorts, corresponds to Asakusa in Tokyo.

The pleasure resorts in the neighborhood of Osaka are: Hamadera-Koyen, on the south, a sea beach covered with magnificent pines, where is a large restaurant (the place attracts many people from Osaka, especially in summer); Takara-zuka, which is famous for the natural mineral water—"Tansan"—and hot mineral water baths. There is an electric tramway from Osaka.

Kobe.

KOBE, which rivals Yokohama in the amount of commerce, is, like it, a child of foreign trade. When it was made a treaty port in 1868 it was a mere fishing-village. It now has a population of 378,000. The American Consulate is at No. 15 settlement; Hongkong and Shanghai Bank at No. 2, Bund; Chartered Bank of India, Australia, and China at No. 26.

CHURCHES:—

Union Church (Anglican and Congregational Services), No. 48,
Roman Catholic Church, No. 37.

The Inland Sea.

THE INLAND SEA is the body of water lying between the Main Island (Hondo) on the north and the two islands of Shikoku and Kyushu on the south. It communicates with the open sea by four passages: On the east by the Narub passage and Akashi strait, on the south by the Bungc channel between Shikoku and Kyushu, and to the west by Shimonoseki strait. From Akashi strait to Shimonoseki it is about 240 miles long, while in width it is from eight to forty miles, the narrowest part being where the province of Bizen approaches that of Sanuki in longitude 134'. The wonderfully picturesque scenery of the Inland Sea baffles description. It is strewn with innumerable islands (more than 4,000 in all) of all sizes and shapes, nearly all inhabited by a half-farming and half-fishing population. Near the shore are seen villages, higher up on the hill sides are cultivated fields in terraces, and the waters are studded with white-sailed junks and smaller fishing-craft. In some places the steamer route is by a

passage that is only a few hundred feet wide, or even still narrower, where there is scarcely room for two ships to pass.

THE SHISAKAJIMA is an island lying in that part of the Inland Sea called Hiuchi Nada, off the great copper-mine of Besshi (in Shikoku). Baron Sumitomo, the owner of the Besshi copper-mine, has a refinery on this island.

MIYAJIMA, also called Itsukushima, is a sacred island and is popularly regarded as one of the three chief sights of Japan. The three chief sights are known as the "Nihon San Kei" and are: Miyajima, Ama-no-Hashi-date, and Matsushima. Miyajima is reached from the city of Hiroshima by a ferry steamer, or by steamer from Shisakajima it is a four or five hour run. The island is 1,800 feet high and thickly wooded. In the lovely valleys, leading down to the sea, among groves of maple-trees, nestle the inns and tea houses for pilgrims to the Itsukushima temple, and the houses of the inhabitants (fisherman and image carvers) of the town (population 3,000). Miyajima is a charming summer resort, the temperature never being uncomfortably high. A number of tame deer roam about the island and will feed out of the hands of strangers.

The temple is dedicated to three Shinto Goddesses, daughters of Susano-o. The first temple was built in the reign of the Empress Suiko (A. D. 593-628). It was, however, in the twelfth century that its prosperity commenced, with its restoration in great magnificence by the then autocrat of the country, Taira-no-Kiyomori. An old custom forbade all births and deaths on the island. Should a birth unexpectedly take place, it is still usual to send the mother and child away to the mainland for thirty days. All corpses are sent across the strait for burial. No dogs are allowed on the island.

The temple enjoys wide renown and pilgrims come to it from all parts of the empire. The great *torii* stands in the sea; and a part of the temple itself is built over the sea on piles, so that at high tide it appears to float upon the water.

THE GREAT HALL OF A THOUSAND MATS (Senjojiki) was, it is believed, built by Hideyoshi out of the wood of a single camphor-tree, and served as his council chamber on the occasion of the famous expedition against Korea at the end of the sixteenth century.

Moji.

MOJI is a fast-growing new town, which, being situated opposite Shimonoseki across the narrow strait (one mile), practically forms one town with the latter. Its growth dates from the opening several years ago of the Kyushu railway and of the numerous coal-mines in its neighborhood. A steam ferry plies every twenty minutes, but the lack of adequate connections between the railway terminus at Shimonoseki and that at Moji is a great drawback to a fast-growing traffic. A scheme is now on foot for spanning the strait with an iron bridge for trains and electric trams. From Moji the Kyushu railway runs, on the one hand, to Beppu, for its mineral hot spring, while on the other it goes through the island to Kagoshima, passing by many populous towns and cities, such as Kokura, Haka-

ta, Kurume and Kumamoto. From Tosu, a few stations from Hakata, a branch line runs to Nagasaki.

THE IMPERIAL STEEL WORKS AT YAWATA is an extensive establishment under the control of the government, which can be reached from Moji in forty minutes by rail.

MIIKE COAL-MINES, owned by Mitsui & Co., are near the Omuta station, on the Kyushu railway, between Kurume and Kumamoto. The location of the mines may be detected for miles by the volume of smoke rising from them.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Mining Industry of Japan.

BY KEIJERO NISHIO,* TOKYO, JAPAN.

(San Francisco Meeting, October, 1911.)

I. Before the Restoration.

1. *First Period.—From Remote Antiquity to 1000 A.D.*

At a time of great antiquity when our Yomato tribe had not yet found its way throughout the country, there lived in Japan barbarous tribes of the stone age, whose dwellings were vertical caves covered with roofs of twigs and weeds. In a cave lately discovered at the village of Morita, 10 miles west from the port of Aomori, there were found pieces of micaceous iron-ore and psilomelane, with oval holes pierced from both sides. Apparently these objects were regarded as ornaments or curios, without being applied to any practical use.

Among the traditions given in the *Nihonshoki*, an ancient history of Japan, there is one relating to the mining industry. According to this tradition, in the mythological age Izanami-no-Mikoto gave birth to Kanayamahiko-no-Mikoto, god of mines, and Amaterasu-Okami (the sun-goddess) was armed with swords. It came to pass at one time that she concealed herself in Ama-no-Iwato ("Heavenly Cave"), and several gods made contrivances to entice her out. Among them, Ishikori-dome, a smith, made a mirror with copper obtained from the Ama-no-Kagoyama, by means of a pair of bellows known as the Ama-no-habuki, which was made of a deer-skin. It is recorded also that Susanō-no-Mikoto, her younger brother, observed the abundance of gold and silver in Korea, where his descendants were to reign, and urged them to provide themselves with boats to convey them across the Sea of Japan. In the course of time he accomplished his object, proceeding to Korea with his son, Isotakeru-no-Mikoto. These accounts

* Engineer of Bureau of Mines, Department of Agriculture and Commerce.

furnish us with a glimpse of the fact that our ancestors in the pre-historic age knew something about the mining industry.

Records for the space of 860 years from the first year of the Emperor Jimmu, 660 B.C., to the conquest of Korea by the Empress Jingu, 200 A.D., show that swords and mirrors were made early in those days, but nothing definite is given as to other metallic products. When the Empress Jingu conquered Shiragi (Sil-la), a province of Korea, the king promised an annual tribute of 80 vessels loaded with gold, silver, silk, and other treasures. This was followed by the surrender of Koma and Kudara (Ko-ku-ryō and Păik-chyöi), two other Korean provinces. The result was a sudden development of communication between Korea and Japan, as a consequence of which scholars, doctors, and makers of various articles, both of utility and artistic merit, made their advent in our country from Korea, and brought the Indian civilization with them. Thus our knowledge regarding the use of metals was considerably improved by Takuso, a smith, who came from Kudara and introduced reforms in the manufacture of metal-wares. In 306 A.D., during the reign of the Emperor Ojin, communications with China supplied the Japanese with a splendid opportunity to bring themselves into a still closer contact with various forms of Indian civilization, which soon spread far and wide through the country. According to tradition, in the reign of the Emperor Kensō, 486 A.D., silver coins were in circulation, which were not, however, the product of Japan. In 552 A.D. Buddhism was introduced from Kudara, Korea. To this religion the Crown Prince Shōtōku became a faithful and enthusiastic convert in 583 A.D., and encouraged its propagation by building numerous temples. As a consequence, there was a large influx of carpenters, sculptors, painters, and artists, creating a demand for metals which was calculated to advance the industry. In 668 A.D., petroleum and asphaltic substances were offered to the court of the Emperor Tenji from the province of Echigo, and in 674 A.D. silver was discovered in the island of Tsushima, to the great joy of the Emperor Tenmu. Silver was offered to the Shinto deities. The governor of the province was raised to the rank of Shōkinge, and honored with several particular favors belonging to that rank, while other officers were rewarded according to their merits. In

691 A.D., the fifth year of the Empress Jitō, the governor of Iyo presented silver and its ores from Miumayama, and Kanzei, a Buddhist priest, made a pigment of white lead.

The people directed their attention seriously to the mining industry, which was specially encouraged under the beneficent reign of Emperor Monmu, full of sagacity and wisdom, from 697 to 706 A.D. During this period the records of mineral discovery stand as follows:

Copper-ore from the provinces of Inaba and Suō; alum from Omi; antimony and its ore from Iyo; cinnabar, realgar, and "shirome" (a speiss or alloy of antimony, arsenic, zinc, bismuth, tin, etc.) from Ise; cinnabar from Hitachi, Bizen, Iyo, Hyūga and Bungo; azurite and copper vitriol from Aki and Nagato; orpiment from Shimotsuke; tin from Tanby, and silver from Kii.

The Emperor sent Itsuse to Tsushima to prospect for gold, while Arakawa was ordered to make researches for gold in the province of Mutsu, and as a result gold was found in the mines of Tsushima, 701 A.D. This pleased the Emperor to such an extent that he gave to that year the title "*Daihō*," signifying "grand wealth," and by way of commemoration of this discovery, Itsuse, the discoverer, was raised in official rank; but alas! to the great disappointment of all concerned, the alleged discoverer turned out to be a fraud. In 699 A.D., the mint, at which copper and silver coins were made, was first established. The zeal of the Emperor for the mining industry was so intense that he took the initiative in the mining-law which is known to us in the famous code, *Daihōryō* issued in June, 701 A.D.

The people enjoyed the liberty of mining copper and iron in all districts where the government was not itself doing so; but even where this was the case, mining was allowed to taxpayers.

In case of a discovery of gold, silver, or curious treasures likely to turn out to be useful, information to the government was to be at once given to that effect.

In 708 A.D., the fourth year of the Empress Ganmyō, native copper was presented from the Chichibu county, Musashi. The Empress, elated with this happy augury, went so far as to change the title of the era to "Wadō," which meant "fine

copper." The discoverers, Kusakabe-no-Oi, Tsushima-no-Kataiwa, and Konjōmu, were exalted to the honor identical with that of the governor of a province, while promotion was extended to the officers concerned. The people of this region were released from taxation, while a general amnesty was granted throughout the country. It was during this year that copper money was made in Omi, and in the year following silver coin also was issued. In 710 A.D., copper money was also made at Dazaifu, Chikuzen. This money was known as "Wadōkaihō" (which meant the treasure made in the era of Wadō), but only a small amount of it is now extant.

The striking increase in the demand for copper encouraged its production; and the system of using copper as a ransom for crimes was adopted. In *Yōrōrei*, a code issued in 718 A.D., it was ordained that for capital punishment was to be paid 263 lb. of copper; for the return from exile, from 98.6 to 184 lb.; and so on.

From the geographical records of the provinces, called *Fūdoki*, published in 713 A.D., it was known that Yamato and Mikawa produced mica; Ise, mercury; Sagami, sulphur and alum; Omi, magnetite; Mino, Hida, Wakasa, Idzumo, and Sanuki, alum; Shinano, sulphur; Kōtsuke, azurite; and Mutsu, rock-crystal, mica, and sulphur.

The dissemination of knowledge regarding minerals brought numerous abuses, and at Dazaifu, where the mint was situated, the people were forbidden, in 716 A.D., to have in their houses the alloy "shirome," which facilitated the production of counterfeit coins.

According to tradition, the discovery of the Osaruzawa copper-mine, Rikuchu, was made in 714 A.D. Copper was produced from Ushijima, Kumage county, and Tariyama, Yoshiki county, Suō, in 738 A.D., and being of good quality, it was mined and smelted as the material for the coinage of the mint in Nagato. The mining of copper- and iron-ore was freely granted to the people at large by the *Daihōryō* of 701 A.D., but the mines were gradually assumed by rich and powerful men, as were also the iron-mines in Omi. Thereupon, such monopolization was forbidden, so as to allow the poor to participate in the industry.

The Emperor Shōmu, 724–749 A.D., was a zealous follower

of Buddhism, and built, in Nara, 745 A.D., a large statue of Buddha in a sitting posture, which was 53.5 ft. high, and of which fine copper was required to the amount of 520.5 long tons, and 7,483.2 oz. of gold. For this purpose, the Emperor encouraged the discovery and production of the two metals. The copper was chiefly mined from the Tada mines, Settsu; the Akenobe mine, Tajima; the Naganobori mine, Nagato, and elsewhere in Chōgoku. Placer-gold was discovered by the governor Kyōfuku (descendant of the King of Kudara), at Wakuya, 25 miles NE. of Sendai. He made a present of 392 oz. to the government. Konjōmu, discoverer of native copper in Musashi, was a Korean; while Kyōfufu, Sumusume, and Kojozan, a smith, who were concerned in the discovery of the placer-gold, were also naturalized Koreans or their descendants. Thus the mining of Japan was greatly indebted to the Koreans.

In 750 A.D. gold was discovered on the coast of Tago, Iohara county, in the province of Suruga. The governor and the discoverer were raised in rank and highly rewarded, and the inhabitants of those districts were exempted from taxes for that year. Several counties north from Taga in Mutsu produced gold, and their taxes were paid in 752 A.D. with 77 oz. of gold. The Tachibana copper-mine, Settsu, became productive, and in Mimasaka magnetic sand was dug from pits. Silver and copper coins were extensively circulated in the year 767 A.D., while in 766 A.D. "shirome" from Hananamiyama, Amada county, Tanba, out of which a mirror was made, was presented to the court, and in 770 A.D. sulphur was mined at Yunotaira, Onuma county, Iwashiro.

As the knowledge of these metals and the crafts utilizing them became disseminated, gold and silver were held in high esteem, as was shown in 646 A.D., in the prohibition of the burial of these metals with corpses. The establishment of the mint at the end of the seventh century increased the demand for silver and copper, and in 815 A.D. the use of gold and silver for ornaments was restricted to the people in certain ranks; while in 834 A.D. the same prohibition was extended to the use of foil and powder of gold and silver through all ranks. The exact amount of the output of gold and silver necessary in those days to meet the demand cannot be gauged. The

provinces of Mutsu and Shimotsuke produced gold, and Tsushima silver, the mine for the latter descending 400 ft. below the surface. In the summer of 864 A.D. it was flooded by heavy rains, and its recovery involved heavy expenses, not supportable by the miners; so that a tax was levied for the purpose of drainage.

According to the *Yengishiki*, published in 927 A.D., the products presented to the government from all provinces were as follows:

Tsushima, 1,168 oz. of silver; Shimotsuke, 192 oz. of placer-gold and 112 oz. of gold-bullion, and Mutsu, 464 oz. of placer-gold. There were also other mines. Records show that in the beginning of the ninth century there were the silver-mines of Ikuno, Tajima; Hosokura, Rikuchu; and Gamō, Inaba. In 902 A.D. gold was abundantly produced from Umegashima, Suruga, while in 970 A.D. Kanase Gorō obtained silver from the Tada mine, Settsu, which was presented to his lord, the famous Tada Mitsunaka. In those days gold and mercury formed articles of trade with the Chinese.

Copper and lead were chiefly produced from such provinces as Nagato, Iyo, Chikuzen, Buzen, and Hizen in the ninth century. The government worked these mines, and built in 818 A.D. a mint for the coinage of copper money at Nagato. At that time the amount of copper minted was 15.54 long tons, and that of lead 7.77 long tons. With the declining production of copper and lead from Nagato, the mint was closed in 868 A.D. But subsequently several mines of Yoshioka, in Bitchu; Okadayama, in Yamashiro; Kafurawariyama and Hichinaiyama, in Mimasaka; Sasayama, in Bizen, and Maruyama, in Iwami, were opened. The government adopted every possible means for the encouragement of the production of the metals either by the impartation of knowledge concerning the art, or by the remission of taxes, or by the supply of miners and smelters. Moreover, the governor of the province was instructed to make a present of a fixed amount of copper or lead; should he make a present of 1.4 long tons of both copper and lead for three years consecutively, he was to be raised in rank. But the supply of these metals was far from meeting the demand. In 940 A.D., the civil war broke out, and the coast of the Setouchi (the Inland) sea was hunted by roving bands of marauders,

by whom the mint of Suō was burnt down. This was followed by the suspension of the official mines.

As previously observed, iron was produced before the eighth century from the provinces of Chūgoku, which were blessed with an abundance of magnetic sand, derived from decomposed granite. In 796 A.D., as the production of iron from Bizen was reduced, the payment of taxes in the shape of iron plows was stopped. It was at the beginning of the ninth century that famous swords made their appearance in these regions. The necessity of military equipments for the provinces on the northern coast of Japan, to guard against threatened invasions, gave birth to famous sword-smiths such as Yasutsuna and his son Sanemori of Ohara (Hoki), who made sharp swords out of the steel produced in these districts.

2. *Second Period.—From 1001 A.D. to 1582 A.D.*

During this period, the production of gold and silver made a gradual but steady increase, particularly in the provinces of Mutsu and Dewa. Fujiwara-no-Kiyohira, the opulent hereditary grand lord of these provinces, built in 1124 A.D. the Chūsonji temple, a splendid building of elaborate workmanship, near Hiraidzumi station on the Tokyō-Aomori route. His grandson Hidehira annually presented 575 oz. of placer-gold to the court. In 1178 A.D., 1,557 oz. of placer-gold from the county of Kesen was presented to Taira-no-Shigemori. After the fall of Yasuhira, son of Hidehira, the large estate, belonging to Minamoto-no-Yoritomo, formed the resources of the Kamakura Shogūnate government. The rich gold-placer was discovered at Shiriuchi, Hokkaidō, during the predominancy of the Shōgun Sanetomo, 1205 A.D. Araki Daigaku, the Lord of Kai, who was despatched with 800 miners to prospect the mines, obtained an immense amount of gold. The placer-gold in Nishimikawa in the Sado province was known about 1000 A.D. The Omori silver-mine, Iwami, discovered in 1310 A.D., produced a large amount of silver from the outcrop.

We may estimate from the following historic records that the industry was extraordinarily prosperous from the eleventh to the thirteenth century. In Chapter II., on the Island of Zipangu, in *The Travels of Marco Polo*, who was the adviser of the Grand Khan Kublai of Yuen, we find the following passage:

"They (the Japanese) have gold in the greatest abundance, its sources being inexhaustible; but the king does not allow of its being exported. Of so great a celebrity was the wealth of this island, that a desire was excited in the breast of the grand Khan Kublai, now reigning, to make a conquest of it, and to annex it to his dominion."

This passage gives the real cause of the invasion by the Tartars, which was brought to an end by their fatal defeat in 1281 A.D. It is curious to note how the tales of Marco Polo at that time excited the brain of a young Genoese and induced him to the discovery of the New World. Later, peace was concluded with the Chinese, with whom Lord Ouchi entered into trade-relations in 1440 A.D. Among the articles of export were gold, copper, and sulphur. These facts, collectively, give a glimpse of the mining industry in those days.

In 1467 AD., the famous civil war of Onin broke out. From that time to the ascendency of Toyotomi Hideyoshi in 1587, the whole country was plunged into the scorching heat of war; nevertheless the mining industry relating to noble metals was not only fortunately undisturbed, but was encouraged by the feudal lords in making provision for their armies. In fact, these mines formed the object of plunder among these warlike tribes. The Omori silver-mine in Iwami producing plenty of native silver about 1530 A.D., offered taxes to Lord Ouchi. The discovery of the Tsurushi silver-mine in Sado, together with the gold-placer washing of Nishimikawa, formed the very coffers of Lord Uyesugi. In 1570 A.D., the Ikuno mine in Tajima produced an immense quantity of silver which proved the rich treasury of Lord Yamana. The Karuizawa silver-mine in Iwashiro, was discovered in 1558 A.D.; its subsequent productiveness resulted in the making of an offer of 17,270 oz. of fine silver to the Lord Gamō. In 1528 A.D., gold was produced from the mines of Suruga, out of which gold coins were minted by Lord Imagawa. About 1540 A.D. the Lord Takeda made 143,930 oz. of gold coin from the mines of Kai and Shinano. These are only parts of the mining industries carried on during the civil war, of which records remain.

The production of copper from the official mines declined in the middle of the tenth century; and the mint being destroyed by the civil war of Tenkei, the coinage of copper money was

suspended, which resulted in the frequent importation from China, by such dignitaries as Shōgun Ashikaga Yoshimasa, of the money necessary for circulation. These facts, however, do not go to prove the decline of the copper-mining industry in those days, since copper was exported by Lord Ouchi, and was also used to make furniture, while descriptions of the prosperity of copper-mines at the beginning of the eleventh century are numerous. For instance, the copper-mines of Nose, in Settsu, and Dōgamaru, in Iwami, became prolific. The mine of Omodani, in Echizen, was discovered. The production of the Yoshioka copper-mine, in Bitchu, was gradually increasing in 1427 A.D.; the Tada mine, in Settsu, produced an immense amount of copper in 1570 A.D.; the Ani copper mine, in Ugo, commenced to be mined in 1575 A.D., and the Motoyama mine, in Mutsu, was also opened about that time. In 1195 A.D., 434.64 long tons of copper were consumed for the purpose of repairing the enormous statue of Buddha in Nara. For the casting of the ponderous bells at Kamakura, in Sagami, and Daigo, in Yamashiro, 1.21 long tons and 13.47 long tons ot copper were used respectively. The Emperor Shirakawa, from 1072 to 1128, made as many as a thousand statues of Buddha. All these facts confirm the belief that copper was abundantly produced in those days.'

It may be interesting to observe that copper-metallurgy made a wonderful progress. The method of matte-smelting, commonly called the "Mabuki" process or "Yamashitabuki," was invented—which is practiced nowadays at small copper-mines, where the Bessemer process could not profitably be applied, as the cheapest and simplest method of matte-smelting. This method has been improved since the Restoration of 1867, by increasing its capacity and reducing the amount of the consumption of fuel. It was invented in the sixteenth century at the smelter of the village of Yamashita, Tada, in the province of Settsu. Formerly the copper-matte produced from the ore-smelting had been first roasted and then reduced to crude copper with charcoal in the hearth. According to the new process, the matte, without preparatory roasting, was melted in the charcoal fire, and the iron and the sulphur in it were oxidized with a strong blast, as is the case in the modern Bessemer process. The process was conducted in the hearth

in which ore-smelting was carried on. The quantity of matte treated at a time was 658 lb., the charcoal being 30 per cent. of the matte, and the laborers required were a smelter-attendant and bellows-pusher for each smelter, Being a greater economizer of time and labor than the reduction process, it has been gradually adopted in the western part of Japan, to the great improvement of the copper industry.

We have but scanty and meager records of the iron industry during this period. At the Sugatani mine, Iishi county, Idzumo, the smelting-plant for magnetic sand commenced to work in 1266 A.D. The method formerly adopted was a very primitive one, called "Noro" smelting. A hearth was made in the ground, in which magnetic sand was heaped and covered with the fuel. When the latter was kindled the magnetic sand became molten and was reduced, leaving the iron mass in the bottom of the hearth. This method of smelting was crude; but the art of making swords, already prosperous in the ninth century, became more perfect than ever, in order to meet the demands of the time. The swords made by Monju in Mutsu, Masatsune in Bizen, Munechika in Kyoto and Okazaki Masamune in Kamakura, form valuable collections at the present day.

The discovery of the Daira lead-mine in Ugo took place about 1270 A.D., and was followed by that of the Obira mine, Bungo, 1547 A. D. This was started as a tin-mine, but later became a copper-mine. In 1469 A.D., at Inariyama, in Chikugo, a farmer found a coal-seam, which is worked at present as the Miike colliery; while in 1532 A.D., at Kurobeyama in the province of Etchu, sulphur was discovered, and three years later it was worked.

3. *Third Period.—From 1583 A.D. to 1866 A.D.*

Gold and Silver.—During this period, gold- and silver-mining, which had been encouraged in earlier periods, made striking progress; and at the time of Toyotomi Hideyoshi the levels of Hyōtanmabu and Daidokoromabu of the Tada silver-mine, Settsu province, were well known for their prosperity. The former derived its name from the fact that Hideyoshi endowed Hara Tanba and Hara Awaji, the heads of miners, with his family ensign of *Sennari-hyōtan* (Thousands of Gourds), and

allowed it to stand at the entrance of the level in honor of the abundant output of gold. The name "Daidokoro-mabu" (kitchen) was given because all the household expenses of Toyotomi were met by the product from this level. Hideyoshi became very opulent, and divided 21,588 oz. of gold and 154,713 oz. of silver among his numerous lords, 1585 A.D. In 1587 A.D. he made silver coins, and in the year following gold coins of different denominations were minted.

At this time Kanamori Nagachika, the Lord of Hida, ordered his vassal Modzumi Sōtei to make researches for useful ores on his estate, and as a result of such efforts, he discovered, in 1589 A.D., the silver-mines of Kamioka and Modzumi and the Otani gold-mine, from which much gold and silver was obtained later. In 1598 A.D. the discovery of the Shrane gold-mine near the Osaruzawa mine, in Rikuchū, was followed by that of the gold-mines of Komagi and Gojūmai in the vicinity.

It is interesting to observe that Sumitomo Jūsai obtained knowledge of the liquation process from a European who visited Sakai, Idzumi province. After that, gold and silver were extracted by this process from crude copper at the copper-refineries in Osaka. The adoption of the new process contributed a great deal to the increase of the output of silver in our country.

The demise of Hideyoshi was followed by the Regency of Tokugawa Iyeyasu, who adopted the proposal of Okubo Iwami-no-Kami concerning the mining industry. He opened for the first time gold- and silver-mines in the Idzu province, at the same time having a control of the Omori silver-mine, in Iwami. In July, 1601 A.D., the gold- and silver-mine of Aikawa, in Sado, afterwards known as the Sado mine, was discovered. This mine became conspicuous by its large production of gold and silver, and was also brought under the control of Okubo together with the Tsurushi silver-mine and the gold-placer of Nishimikawa. It was during this year that gold and silver currency was coined in abundance. In 1602 A.D., the bonanza of the Waremabu of the Sado mine was prosperous, producing 1,199,327 oz. of gold and silver, which fortune was shared by the Kamayamabu level of the Omori mine, where the silver-yield amounted to 603,946 oz. Several mines in the Idzu province became strikingly productive, the Nawachi silver-mine being particularly conspicuous, since it formed an object

of Iyeyasu's pride. At the Ikuno silver-mine, the Tsukimabu level was productive in 1585 A.D., and was followed by the Sanzensanbyakumai lode about 1600 A.D. The Shirane gold-mine also became productive beginning with the year 1602 A.D., and actually produced 5,277 oz. of gold in 1604 A.D.; this year was blessed by the discovery of the famous Innai silver-mine at Ugo.

Notwithstanding the prosperity of the mines and the rich new discoveries above described, the government did not relax its efforts to develop the mining of these valuable metals. In 1606 A.D., Watanabe Bingo and Sunimokura Genshi were ordered to prospect gold- and silver-mines throughout the country for the encouragement of the production of these metals.

The mining of gold- and silver-ores in those days was only the excavation of the enriched zone above the drainage-level, but as in the course of operations it became necessary to sink below that level, the difficulty of drainage was felt. In 1607 A.D. the productive capacity of the mines of Sado and Idzu became exceedingly diminished, in all probability on account of water, so that 36 mining-experts, selected from Omori mine and the mines of Idzu, were sent to the Sado mine to reform the operation; but in spite of all their efforts, the mine was frequently swamped by water in the rainy season. In the course of his attempt to revive the production of noble metals, Okubo attempted to wash for placer-gold at Shiriuchi, Hokkaido; but the effort proved abortive, owing to the objection raised by Lord Matsumaye Kimihiro, who urged that, since the excessive rigor of the cold climate prevented the cultivation of the land, he was not in a position to find sufficient provisions for the numerous miners. In 1614 A.D., as the Innai silver-mine was troubled by water, the expense for drainage was advanced by the government.

In those days, for the purpose of drainage in the Sasu silver-mine, Tsushima, a treadmill was used. In the Sado mine a well-bucket only was used, which was worked by prisoners convicted of capital offences. In 1634 A.D., the "Supondoi" was adopted—a primitive hand-pump consisting of a wooden pipe 4 in. square and from 9 to 12 ft. long, having a valve 3 ft. below the upper mouth, and a piston 3 ft. long, with a valve

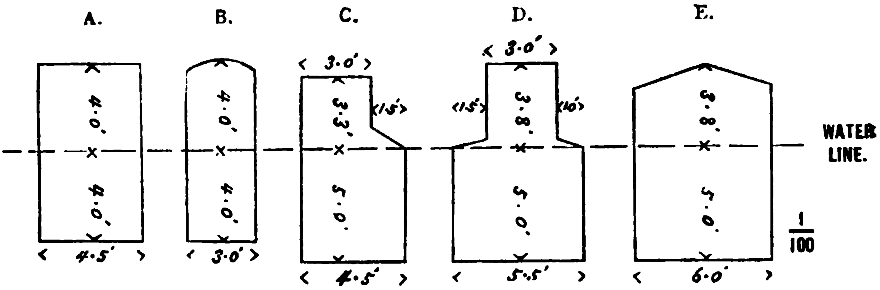
at its end. In 1637 A.D., Sōho, the hydraulic engineer, who came from Osaka, designed the "Tatsudoi," which took the place of the "Supondoi." It was an Archimedean pump of Roman style, which consisted of a wooden cylinder and screw, 9 ft. long and 1 ft. in the upper and 1.2 ft. in the lower diameter. The ruins of such a pump were lately found at the old working-place, and are now preserved in the Tokyo Imperial University.

The pumps served their turn well in those days. In 1644, the output of the Ikuno silver-mine also declined by reason of the difficulty of drainage. It was at this juncture that Tomomatsu Dōhan mined the levels of Kanaki and Kawato, employing 1,500 persons for pumping, and in the course of two years obtained 35,980 oz. in silver. As the expense of drainage grew enormously heavy in the Sado mine, various taxes were levied from the province in order to meet the deficit. In 1872 A. D., a hand-pump, introduced from Holland, was successfully worked at Aoban and Jingo in the Sado mine, saving £707 per annum from the cost of draining, which in the year following was used to cut an air-way at Seiji level, which had been abandoned on account of bad ventilation.

As the drainage grew to be a serious question for mining, the excavation of the adit was started, utilizing the topographical conditions. In the Sado mine, the adit of Midzukane ravine, whose length was 2,880 ft. through andesite tuff, was commenced in 1629 and completed in 1639. The adit of Ogiri, begun in 1647, was completed after the constant work of 13 years. Its length was 948 ft., and that of the accompanying air-way 1,080 ft. Lastly the adit of Minamizawa ravine was undertaken, which remains to this day. It was commenced July 25, 1691, to drain the water in the working-places at the Waremabu bonanzas. May 14, 1696, success was attained after five years of effort. The length of the adit was 3,014 ft. It was driven from six points, making two intermediate shafts at the Kitazawa ravine. The sections of the adit were made in several forms besides the common rectangular form, in order to reduce the upper pressure and to enlarge the flowing-area, as shown in Fig. 1.

The monthly progress at each working-face was 8.6 ft. through andesite tuff. The excavation was done with chisel

and hammer, making the surface of the wall and the roof very even, and leaving the traces of the chisel. A part where the trace resembles the spider's web, is celebrated as the *Kumonosu-Kengiri.* During the excavation the working was ventilated by brattice. The surveyor of the work was Shidzuno Yoemon who used the magnetic compass and clinometer, which are now preserved at the Tokyo Imperial University. The circumference of the compass is divided into 480°, and each of these into 10 min. and E and W are placed as in the modern compass. The clinometer is 1 ft. square, its scale being divided into 10 *sun* and each *sun* into 10 *bu.* The art of mine-surveying in those days may be inferred from a mine-map, which was made in 1695 A.D., now preserved at the Tokyo Imperial University.



Common form Kakugata. (Rectangle.)

Norimonogata. (Section in the form of Japanese palanquin.)

Katafuigogata (Section in the form of Japanese bellows.)

Ryōfuigogata. (Section in the form of Japanese bellows.)

Shōginokomagata. (Section in the form of Japanese chess.)

FIG. 1.—THE SECTIONS OF THE MINAZAWA ADIT, THE SADO MINE.

In the Ikuno mine, the adit of Rōmabu was driven in 1608; and in 1638 a drainage-level was excavated from Takeharano for the whole mine. In 1715, the adit Shinkiriyama of the Omori silver-mine was commenced. At the Handa silver-mine an adit was begun in 1741, and its completion in 1746 effected a sudden increase of the output of silver. In 1786, other adits were projected. In the mines of Tada in Settsu, however, owing to typographical conditions, adits could not be effectively used, and the drainage had to be performed by manual labor. Consequently, even in rich bonanza, it was next to impossible to work below certain horizons, and the work had to be abandoned.

In ancient times, much difficulty was experienced in the transportation of supplies and products. As the metal-mines were always situated in mountainous regions, the provisions for miners had to be brought from distant places; and in seasons of famine, it was a serious question how to keep a vast number of working-men from starvation. In the famine of 1642 the Karuizawa silver-mine (Iwashiro) had to be abandoned, but the Ikuno mine escaped a similar fate by working the bonanza of Sanzensanbyakumai lode. In the famine of 1643 the Sado mine was a great sufferer.

Through the efforts made by Okubo Iwamino-kami for the production of the valuable metals, the mining industry made a rapid and healthy growth. In the Ikuno mine, levels turned out to be very prosperous in 1622, yielding a rich ore (0.4 to 0.6 per cent. Ag), and the monthly output of silver was 21,588 oz. The total product of gold in Japan in 1630 was 23,061 oz., of which 11,889 was from Sado, 9,454 from Satsuma, and 1,420 from Idzu. In 1634, the Nobezawa silver-mine, Uzen, became productive, and was converted into a government undertaking, and in those days, there were 53 productive levels. The production of 1635 from the Ikuno mine was 143,917 oz. of silver. The province of Satsuma was known from ancient times as the chief gold producer. In 1638 the discovery of the famous Yamagano gold-mine was made, producing 31,380 oz. of gold annually; and another discovery occurred in the well-known Serigano gold-mine in 1652. In 1664, the decline of the Sado mine became decisive. It yielded only 117,509 oz. of silver, owing to the water trouble at the Waremabu bonanza; and it was finally abandoned. Though the Ikuno mine had been thus impoverished in 1644, it gradually regained its capacity after 1668, and in 1671 it was producing 119,932 oz. of silver per annum. In 1669, the ore of the Osaruzawa gold-mine was changed into copper-ore, and it is now being worked as a copper-mine. In 1674, the working Suwamabu, in the Waremabu bonanza of the Sado mine, furnished ore containing 0.29 per cent. of silver and produced 5,037 oz. of silver in 10 days. The annual output of silver of that year is given as 239,599 oz. The Ikuno mine declined after the prosperity of 1671, but was fortunately checked by the flourishing condition of the Ryōgokuyama

level. Thus in 1683 it produced 42,785 oz. of silver, and in 1696 the output amounted to 111,092 oz. of silver.

In the sixteenth century, the European ships visited the western shore of Kyūshū, at Hirado, Gotō, Hizen, and Satsuma, and entered into commerce with the natives. The amount of gold and silver then exported by the Portuguese was enormous. In 1607, the Dutch ships were granted permission to trade at any ports in Japan. After the Christian massacre at Shimabara, 1638, the trade was confined solely to the Dutch, Chinese, and Koreans at Nagasaki. The decreased production of silver in Japan raised its value exceedingly, so that in November, 1662, the value of 1 oz. of gold was equal to that of 12 oz. of silver. In order to decrease the amount of silver exported, the gold exportation was granted in 1664, and the rate of exchange was 1 oz. of gold equal to 14 oz. of silver. The amount of silver and gold exported by the Dutch and Chinese vessels during the 20 years, 1648 to 1667, was 33,222,559 oz. of silver and 55,472 oz. of gold. The outflow of silver was not decreased, so that the exportation of gold and silver was summarily prohibited in 1668. In 1672, in trading with the Dutch, the use of gold and silver was permitted at the request of the latter, on the ground that unless silver were brought to their country from Japan, silver would be highly appreciated in Holland, causing great difficulty in business. In 1685 a limit was put upon the total amount of trade to be done, guarding against the reckless export of gold and silver; but the foreigners invited the merchants of Japan to private trading on the sea. Thus the exportation of gold and silver was not altogether stopped. The total amount of precious metals exported during 164 years, 1601 to 1764, was 3,763,572 oz. of gold and 135,768,918 oz. of silver. With the diminution of gold and silver currency, commerce in Japan was much disturbed, and the limited production of those metals from our mines was far from satisfying the demand. Hence, to increase the amount of currency, the recasting of the old coins, lowering their fineness, was commenced in 1695. This proved to be a failure, as may be seen in the rise of the price of commodities. Under the circumstances, the increase and improvement of coins formed a subject for serious debate in those days. In August, 1695, it was declared that, if one found mines of gold, silver,

or copper, he was at perfect liberty to mine the same at his discretion.

In 1697 they began to use, in the Sado mine, stamps driven by water-wheels to crush the poor ores formerly abandoned. The annual output of that mine in 1703 was 18,788 oz. of gold and 667,636 oz. of silver. The Ikuno mine was prosperous in 1709, yielding 123,495 oz. of silver. The total output of silver in Japan in 1711 was 479,731 oz., and that of gold, 7,533 oz. In 1716 the Sado mine was greatly impoverished, producing only 131,802 oz. of silver. In 1726 rich ores were produced from the Shinkiriyama adit of the Omori mine, and the output of that year was figured at 64,053 oz. of silver. In 1767 the Ikuno mine produced 82,920 oz. of silver.

In 1771 the Sado mine produced 5,177 oz. of gold and 621,806 oz. of silver. It is very curious to observe that the methods of rugging and concentrating the ore at that mine were identical with those of Cornwall in ancient times, as may be seen from the following description: The ore was at first brought into the rugging-room, *kanaba*, where a slab of andesite was prepared on a base which was 3 ft. high and 3 ft. wide, at the front of the window. There it was rugged into slime with a hammer, and then was sieved with a fine screen. The slime was introduced into *tateoke*, a dolly-tub, with water. After stirring with a ladle, the side of the tub was beaten to settle the deposit. The concentrates were subjected to vanning with a plate vanner. The headings were made into balls and roasted on a charcoal-fire. Then the roast was smelted with lead, 50 per cent., and iron, 5 per cent. The lead produced was cupelled; the matte was also smelted to absorb silver into the copper; the latter was liquated; and then the lead was also cupelled. The auriferous silver was smelted with sulphur, producing silver-matte and silver rich in gold. From the former the sulphur was driven, and the silver was absorbed in lead, which was then cupelled. The latter was crushed fine, then piled in a conical form on a porcelain basin, mixed with common salt, and roasted. The roast was washed to separate the silver chloride from the gold. The silver chloride was filtered and cupelled. The silver was considered very fine at that time, but it contained 0.61 per cent. of gold. The gold-bullion produced was 995.4 fine.

Tanuma Mototomo, a favorite of Shōgun Iyeharu, undertook to prospect for gold at the Mt. Kimbusen in Yamato and Chichibu in Musashi. The former place was reported as rich in ancient times. After unsuccessful working for several years, the work was stopped in 1786, when the Shōgun died.

In 1804, the Aoban and Torigoye stopes of the Sado mine were impoverished, reducing the output to 578 oz. of gold and 6,623 oz. of silver. The Yamagano mine, Satsuma, also declined in 1805, producing only 1,775 oz. of gold annually. The Ikuno mine produced only 33,821 oz. of silver that year, but gradually recovered, and produced 85,152 oz. in 1812. In 1814, the Omori mine became prosperous, yielding annually 27,618 oz. of silver. The Innai mine was productive, yielding annually 57,251 oz. of silver from 1741 to 1817. In 1823, the Sado mine made some profit after 28 years of loss; but its production did not exceed 1,186 oz. of gold and 30,147 oz. of silver. In 1840 the production of the Handa mine was increased by draining the water in the Okutate and by the opening of the Nikaimabu. Its annual output, for 146 years from 1719 A.D., was 17,037 oz. of silver. In 1861, the Kosaka silver-mine, Rikuchu, which is nowadays the champion copper-mine in Japan, was discovered. After five years Lord Nanbu built a shaft-furnace and a cupelling-hearth to develop this mine; but it was disturbed by the civil war of 1867.

Copper.—At the end of the sixteenth century the Kawakami mine, in Harima, and the Hitachi mine, in Hitachi, were discovered, and the Maruyama mine, in Iwami, was prosperous, which was followed by the discovery of the Gamō mine at Iwashiro. In 1610, the Ashio mine, in Shimotsuke, which is now the largest mine in Japan, was discovered. The Yoshioka mine, Bitchū, was prosperous at that time, and was converted to be a government mine in 1642, yielding 30 long tons annually. The Ashio mine was also developed and became a government mine in 1647. In 1669 the Osaruzawa gold-mine was changed into a copper-mine as mentioned above. In 1670 the Ani copper-mine was discovered. Thus the copper-mining industry made a slow, but steady, progress.

In copper-mines, as in those of the precious metals, the working is easy when the excavation relates to the upper part near by the outcrop, but the difficulty caused by water arises

when depth is reached. Hence in the middle of the seventeenth century the Naganobori mine, in Nagato, and Maruyama mine, in Iwami, which were productive, had to be suspended on account of difficulty of drainage. The Yoshioka mine was brought into working order only by the excavation of several adits.

In the fifteenth century copper was exported by Lord Ouchi to China, and this trade continued to thrive in the time of the Tokugawa Shogunate. In 1638 Sumitomo Rihei and 21 merchants were granted permission to trade copper with foreigners, whereby the amount of export was greatly increased. But in 1668 the export of copper was prohibited, together with that of gold and silver. Sumitomo Kichizaemon enjoyed the special privilege of exporting copper, since his ancestors had been engaged in the trade since 1573. At the time under consideration there were 23 copper-mines in working order, which after the lapse of 17 years, were increased to 34. Of these the Ashio mine stands conspicuous for its prosperity, as it produces 1,488 long tons per annum, which is followed by the Yoshioka mine, producing 1,175 long tons annually. The total annual production of copper at that time was 5,357 long tons, from which 13,648 oz. of silver was liquated. One-ninth of the copper was consumed in Japan, while the rest was exported. The laborers in copper-mines numbered 200,000, and those engaged in liquation at the copper-refineries at Osaka, 10,000. In 1688, as the Ashio mine was declining, the capital for recovering was advanced by the government, but the recovering process involved a great amount of difficulty. In 1690 the engineers of Sumitomo Kichizaemon, who was working the Yoshioka mine, discovered the Besshi copper-mine, Iyo, one of the largest mines in Japan, in which mining was commenced in the following year under the government license As the deposit was a very extensive cupriferous pyrite bed in the crystalline schist, it produced 178.5 long tons of copper in the first year, and in 1694 595.24 long tons annually. The year 1700 was also signalized by the discovery of the Arakawa mine in the province of Ugo. In August, 1695, the government urged the opening of the copper-mines with the mines of gold and silver, to increase their production to satisfy the demand.

In 1689 the amount of copper to be traded was fixed, so that the Dutch used to have a certain amount of commodities left untraded. In 1689 A.D., Fushimiya, a merchant in Nagasaki, applied to the government for permission to purchase these goods with copper, within a specified limit, which was granted. Thereby the export of copper was raised to 5,298.8 long tons in 1697, while, at home, the supply did not meet the demand. In 1702, the government summoned Sumitomo Kichizaemon to Yedo to undertake the increase of the production of the mines of Besshi and Yoshioka, which he was working. Acting under the suggestions of this experienced miner, the government advanced 5,000 *ryō* as a mining capital for the Besshi mine, and the same amount for the excavation of an adit for the Yoshioka mine; and as the former was located in a mountainous region which was handicapped in communication-facilities, 30,914 bushels of rice was granted by the authorities to purchase at nearly one-half of the market-price; and the products from these mines were extensively exported. It was in this wise that the so-called "government copper-mines" were brought into existence, of which the government required a certain fixed amount to be produced for specific objects, leaving any surplus to the disposal of the miners.

In 1711, the total output of copper in Japan was 3,809.52 long tons, of which 2,857 long tons was exported. The amount of the exportation fell in 1715 to 2,628.60 long tons, of which 1,785.74 long tons was exported to China and 843.60 long tons to Holland. In 1728 the exported copper amounted to only 758.83 long tons, that is to say, 245.54 long tons from the mines of Akita, 60.36 long tons from those of Nanbu, 395.33 long tons from the Besshi mine and 53.60 long tons from the Yoshioka mine. In March, 1736, the government urged the starting of the mines of copper, lead, or tin, with the purpose of increasing the production, and promised various facilities, as a consequence of which the Kune copper-mine (Tōtōmi) and the Kusakura copper-mine (Echigo) were discovered.

Copper for exportation was collected by the merchants at Nagasaki, but the amount never equaled the demand. After 1738, copper was collected at the Osaka Copper Office and sent

to Nagasaki, thus affording every possible facility. In 1754 the amount of copper supplied from the government copper-mines for export was 1,586.01 long tons, of which 734.27 long tons were contributed from the mines of Akita, 428.81 long tons from those of Nanbu, and 422.94 long tons from the Besshi mine. But later the amount was necessarily decreased by reason of the diminished productive capacity of the Akita mine.

The price of copper purchased by the government from the government copper-mines was 361 oz. of silver per long ton of copper, as in the Besshi mine. In 1750, it was reduced to 279 oz. of silver, against the market-price of 420 oz. Hence Sumitomo, the owner of the mine, petitioned frequently to raise the purchase-price, without avail. In 1767, the government price was raised to 305 oz. of silver; but, as the production of copper was scanty, the market-quotation was much higher. Consequently, such an honor or title as to be called "the government mines" was regarded as rather a sort of misplaced kindness to the owners of the mines; but it appears that in spite of the contrary statement made by them, the government's protection certainly went a long way to help them. The price of copper for the Chinese trade was 231 oz. of silver per long ton of copper, and that for the Dutch 121 oz. Hence the copper trade of those times involved heavy losses. Moreover, the "Kakeire Dō" (or surplus copper to fill up the losses of transportation) was added at the rate of 1 per cent. for Dutch export and one-third of one per cent. for Chinese.

The Ashio mine, which had been included in the list of the government mines, was excluded by its decline after 1736. For five years, beginning with 1742, the mine was authorized to cast a copper money known as "The Kanyeitsūhō," which was specified with a letter, Ashi, from the name of mine, on the back surface. In 1747, the annual output of copper amounted to 110.14 tons. The government spared no energy to bring about an increase of production; and in 1763, instructions were issued to the effect that copper-mines, which had been suspended or left untried, should be thoroughly investigated, and that the government should be informed of the results. In 1775, the government itself started to prospect copper-ore at the Mt. Kurama, near Kyōto. By such hard

work the production of copper was increased, while the demand for export was satisfactorily met.

At the end of the eighteenth century, the Daikoku lode of the Omodani copper-mine, in Echizen, was discovered, which offered to the government 73.8 long tons of copper. It was about this time that the excavation of an adit at the Sasagatani copper-mine, in Iwami, was started, but not meeting with ore-deposits, the attempt ended in failure. In 1821 the Ashio mine had finally to be abandoned; but the Besshi mine was prosperous, yielding from 400 to 600 long tons of copper per annum; and about 1840, the Tenwa copper-mine, in Yamato, and in 1865 the Hōmanzan copper-mine, in Idzumo, were discovered, and almost simultaneously a wide vein was found at the Gamō copper-mine, in Inaba, which proved to be quite a prosperous one. In 1860, the export copper supplied from the government copper-mines was 1,086.71 long tons, of which 352.44 tons was produced from the mines of Akita, 311.32 tons from those of Nanbu and 422.93 tons from the Besshi mine; the mines of Tada, in Settsu, were productive for 189 years from 1662 to 1868, producing 7,152.40 tons of copper—with the exception of 18 years in the interval during which the work was suspended.

For 85 years, from 1755 to 1839, the copper exported by Dutch vessels was 39,042.80 long tons, and that by Chinese vessels was 61,411.87 long tons. For 257 years, from the year of the inauguration of the Tokugawa Regency, 1601 to 1857, the total amount of the exported copper was reported to be 319,922.15 long tons; that is, the annual export was 1,244.85 long tons.

The excavation of rocks and ores was formerly effected by means of chisels and hammers, but where they were hard, fire-setting was sometimes used, as at the Nawachi silver-mine, in Idzu, and in the Besshi copper-mine, to facilitate the mining of the ore. The excavation by such means must have been slow and tedious. In 1862, Raphael Pumpelly and W. P. Blake, both American engineers, and Oshima Takatō, introduced for the first time blasting with gunpowder at the Yūrrapu lead-mine, in Hokkaido, which was considered as a forerunner of the new working of the mining industry during the present *régime*.

Iron.—Iron was formerly smelted from the magnetic sand produced from decomposed granite which occupies the mountainous region of Idzumo, Iwami, Bitchū, Bingo, and Aki. Owing to the progress of society and the consequent increase of the demand, the iron industry has grown to be quite prosperous. In the valley of the Tōjō river, Bitchū, places worked for magnetic sand numbered 267 in 1671, from which the inference may be drawn of the remarkable growth of the business, which must be attributed to the great protection rendered by the feudal lords. It is quite an opportune time to describe the remarkable invention of balance bellows in Iwami at the beginning of the eighteenth century.

In the iron metallurgy, the tread-bellows, "Fumidatara," was formerly used, which required eight men to operate. The new balance bellows, "Tenbindatara," which was invented in the eighteenth century, needed only two men for the pair to produce the same effect. This saving of smelting-expense was conducive to the remarkable development of the industry. As a consequence of this growth a conflict of interests with farmers began to arise. For instance, in 1846, the people in the valley of the Takahashi river (Bitchū) lodged complaints with the government to stop the washing of magnetic sand on the upper course, because the water of the river became thereby so turbid that it was utterly unfitted for irrigation, and the river-bed was raised high by sand deposits. Through the arbitration of Lord Asano, the matter was brought to a successful issue on the ground that the washing was executed at the time when agriculture was inactive. Another industry was started in Tosa in 1782, and the magnetic sand on the coast of the Hokkaidō became the object of attention. In 1801, permission was asked for the smelting of iron in the environs of Hokodate, but was not granted by the government. In 1855 Takenouchi Yasunori and Takeda Hisaburō built shaft-furnaces at Kobui, Oshima, Hokkaidō, to smelt magnetic sand from the coast. This was the first one built in Japan. The Kamaishi iron-mine, Rikuchū, was discovered in 1823, where the smelting was commenced in 1849, and in 1860 shaft-furnaces were built by Oshima Takatō to smelt the iron-ores. In 1857, the Kamiteoka (or Kamichūka) iron-mine (Iwaki) was discovered, where tread-bellows were used in smelting ores.

Other Metals.—With reference to other metals, the want of records prevents a complete description. Lead was chiefly produced from the silver-mines; the output of this metal in 1710 was 14 long tons. Tin was mainly produced from the Taniyama mine, in Satsuma: the output being 76.36 long tons in 1849, but in 1859 it was reduced to 17.62 long tons. Antimony was produced from the Ichinokawa mine, Iyo, 1736 A.D., and used for the preparation of drugs and alloys.

Coal.—In the counties of Onga, Kurate, and Kaho, in Chikuzen, which are the important coal-fields in Japan at present, coal has been produced since 1702 in a somewhat limited degree. In 1721 the coal at Hiranoyama, in Miike coal-field, in Chikugo, began to be worked. This was followed by the discovery of the coal-seam of the Yoshinotani colliery; and in 1800 Goheida, a native of Hirado, discovered the Takashima colliery in the province of Hizen—and in these districts coal was known as "Goheida," after the name of the discoverer. In those early days, coal was chiefly used for domestic purposes, but sometimes it was sold as a fuel in the salt-fields in Setouchi coast or to foreign steamers visiting Nagasaki. In 1843, Matsumoto Heinai started a coal-store at the port of Ashiya, in Chikuzen, where he monopolized the business of the coal, eggs, and crude wax produced in that province. In 1855, a steamship was sent as a souvenir to the Shōgun by the King of Holland. This suspended the export of block coal from Chikuzen, since it had to be used as fuel for the steamer. The maximum output of coal from the province of Chikuzen was fixed by Lord Kuroda at 60,000 long tons annually. Coal-mining in those days was simply cutting from the outcrop, and hence there was every need for improvement. In 1855, the Oura slope of the Miike colliery (Chikugo) was started. It reached success in four years, when the coal-seam was met at 230 ft. on the slope, or 40 ft. vertically. The Takashima colliery introduced in 1867 the European method of mining.

Petroleum.—The petroleum in Echigo was formerly obtained from ditches excavated along the petroleum-seepage, as seen at Kurokawa. This was, however, changed in 1818 to the pit-

sinking method. The utilization of the natural gas from the oil-fields of Garameki village, Kanbara county (Echigo), was projected early in 1613, attracting but little attention on the part of the people.

At the end of the Tokugawa regency the country was in a troubled condition, whence the mining industry was also disturbed, and at last stopped during the civil war ending with the Restoration of 1867, which has given a happy chance for mining development.

From the earliest times on record several persons have devoted themselves to the development of the mining industry in Japan. Especially is Modzumi Sōtei, in Hida, worthy of mention for his great efforts in this cause. Naturally, after his death, he was revered and deified by the miners in that region. At the beginning of the Tokugawa regency, Okubo-Iwamino-kami-Nagayasu exerted himself, as described above, to work the gold- and silver-mines, so as to build up the natural resources. When the trade was started with foreigners, an enormous amount of gold and silver was taken from Japan, which reduced the domestic supply to such an extent that the scarcity of coins in circulation was keenly felt, while the export of copper was no less large; so that at the end of the seventeenth century the development of the mining industry was the most serious question of the time. At this juncture, Japan was blessed by the birth of a hero at the northeastern part of Honshū, whose name was Satō Nobukage. He was born at Nishimaonnai, Okatsu county, in Ugo, in 1673 A.D., and acquainted himself with the science of administration and agriculture after his father Nobuhide. He opened the Matsuoka silver-mine (Ugo), and worked it, as he has explained in the *Kōjōhōritsu* (*The Administration of Mines*), 1683–1703. Later, he mined the tin-mine at Ashio, Shimotsuke, 1704–1710, and the tin-mine at Takeda, Bungo, 1716–1731. He is the author of *Sansōhiroku* (*The Principles of the Exploitation of Mines*), which contains epitomized accounts of his rich experience. In August, 1731, at the invitation of one of his pupils. he paid

a visit to the Ani copper-mine in Ugo, where, in the course of his examination underground, an explosion of gas ended his glorious and promising career.

There are even to these days many miners in the provinces of Mutsu, Dewa, Iyo, Tajima, and Iwami who have full confidence in his principles of the exploration of mines. His son Nobusuye was quite equal to his father in point of scholarly attainments, and in 1781 he prospected the gold-mine at Shinjo, Uzen, and then he visited the Ashio copper-mine, where he taught a liquation process. In 1784, while he was devoting himself to reopen the tin-mine which his father had owned, he was affected by poison from the arsenious acid, which proved fatal. His son, Satō Nobuhiro, was educated by his father and by celebrated scholars in Yedo in those days, and, accepting the request of his pupils, he examined the Ani copper-mine. Since his scholarly attainments were far in advance of the requirements of the time, he had to retire to Kadzusa from public life, in order to avert the suspicion of the government. Then he devoted himself to the reform of household science, and wrote 60 volumes on agricultural administration, besides revising his grandfather Nobukage's *Sansōhiroku.* He reduced to writing *Kōjōhōritsu,* which was inherited from his grandfather by oral teaching, as his son was too young to understand and remember it. He passed away Jan. 6, 1850.

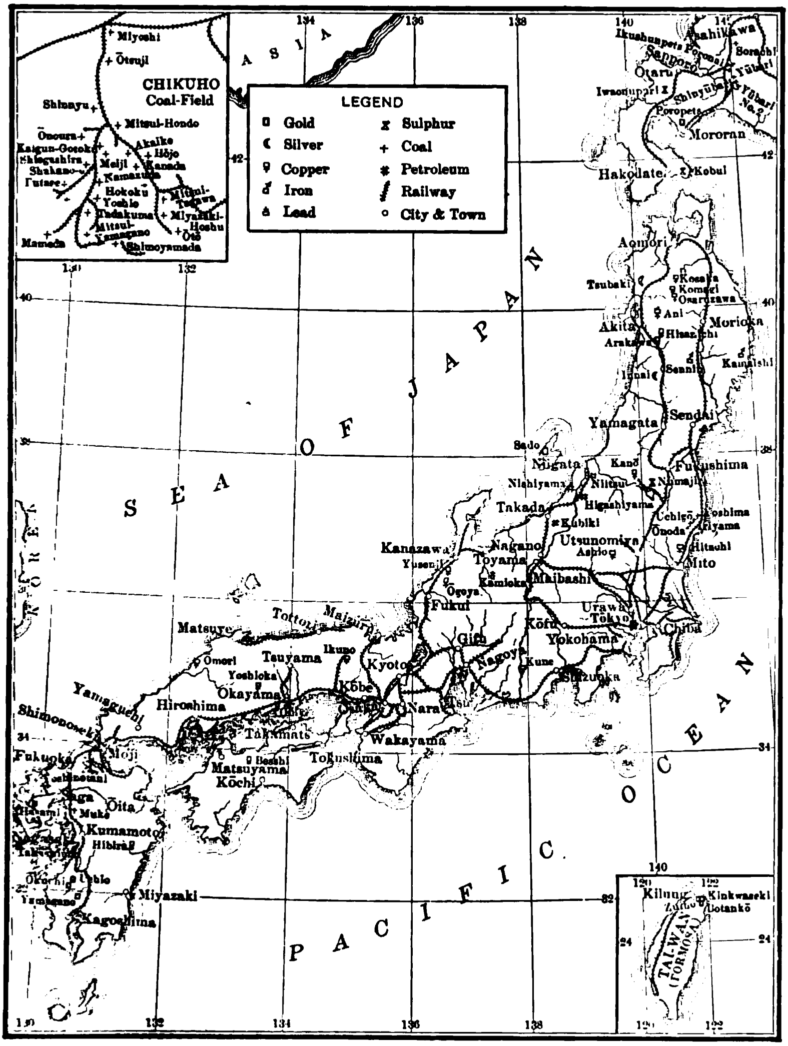
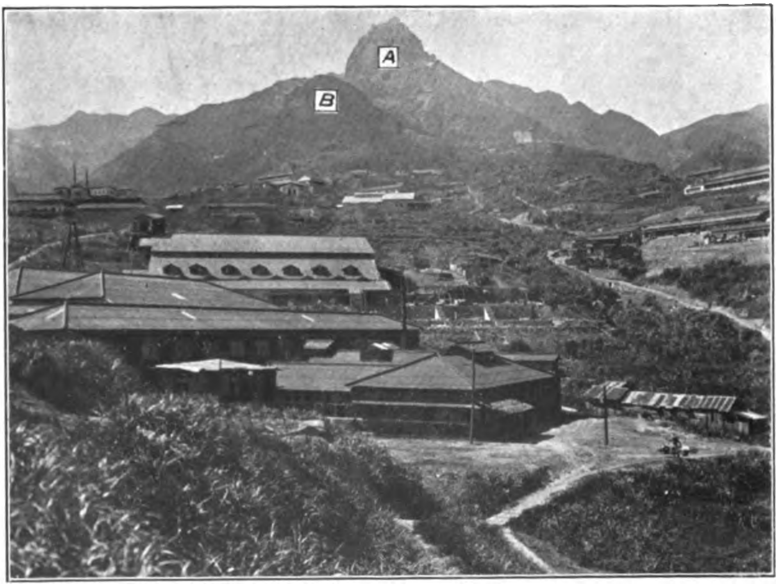


FIG. 2.—MAP OF JAPAN, SHOWING IMPORTANT MINES.

A. The Dōyū Outcrop.
FIG. 3.—THE SADO GOLD-MINE.



A. The Daikinkwa Outcrop.
B. The Mayekinkwa Outcrop.
FIG. 4.—THE KINKWASEKI GOLD-MINE, FORMOSA.

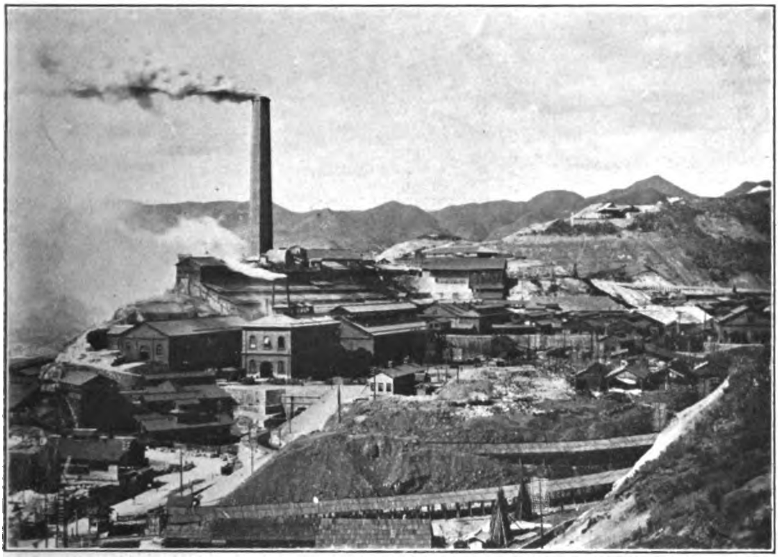


Fig. 5.—The Kosaka Copper-Mine.

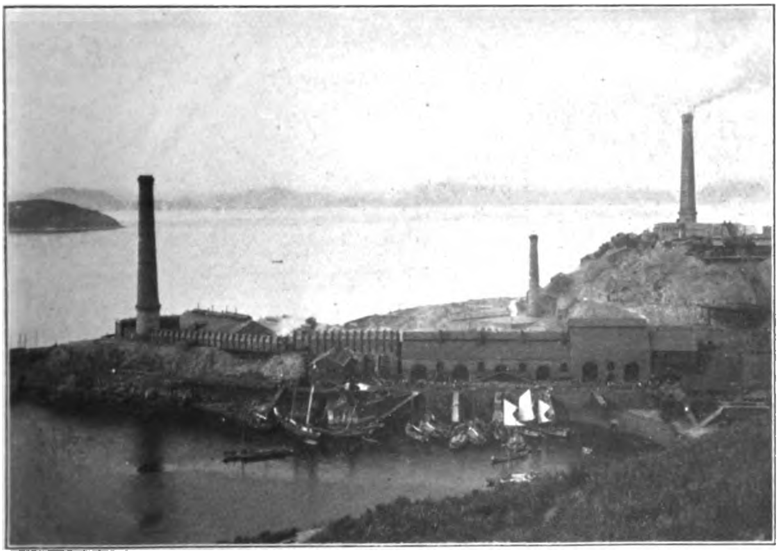


Fig. 6.—Smelting-Plant in Shisaka Island, which belongs to the Besshi Copper-Mine.

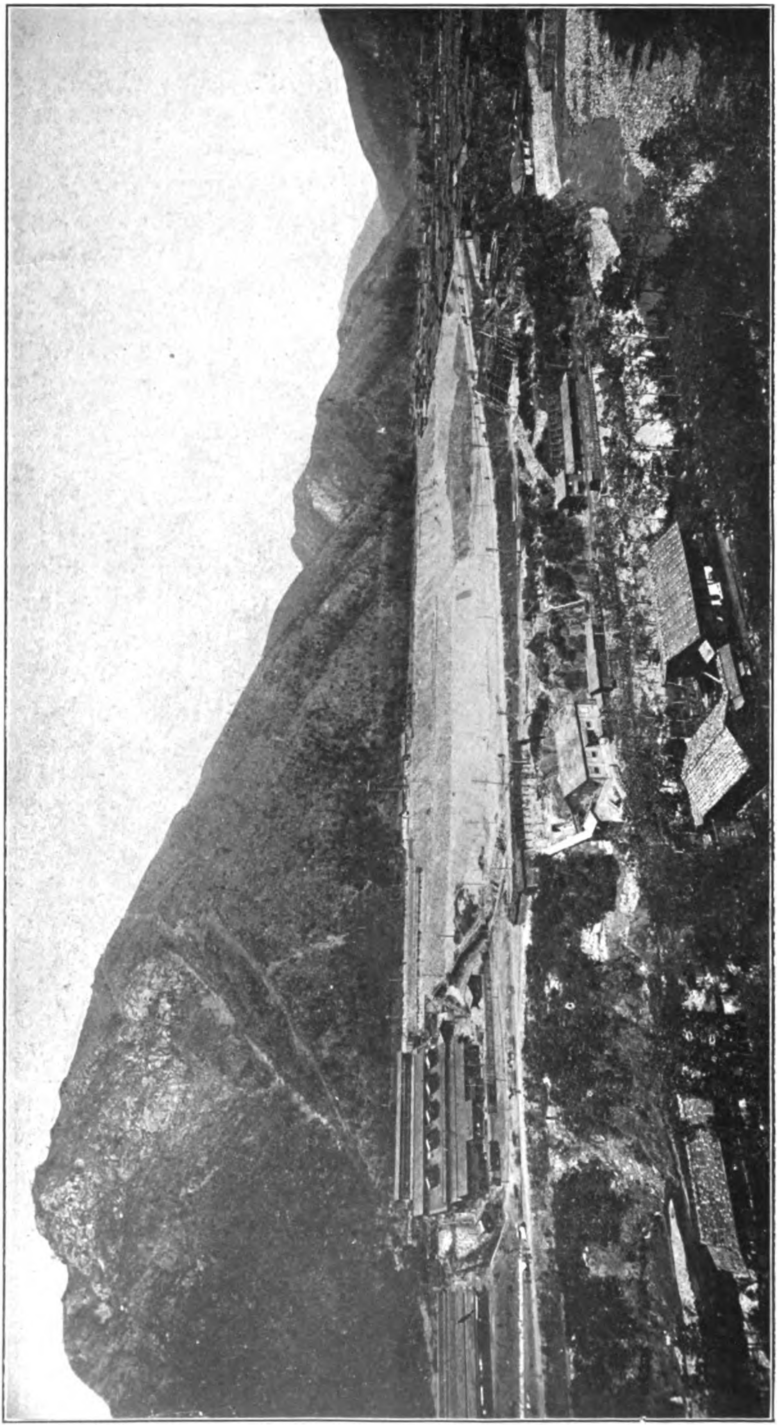


FIG. 7.—THE ASHIO COPPER-MINE.

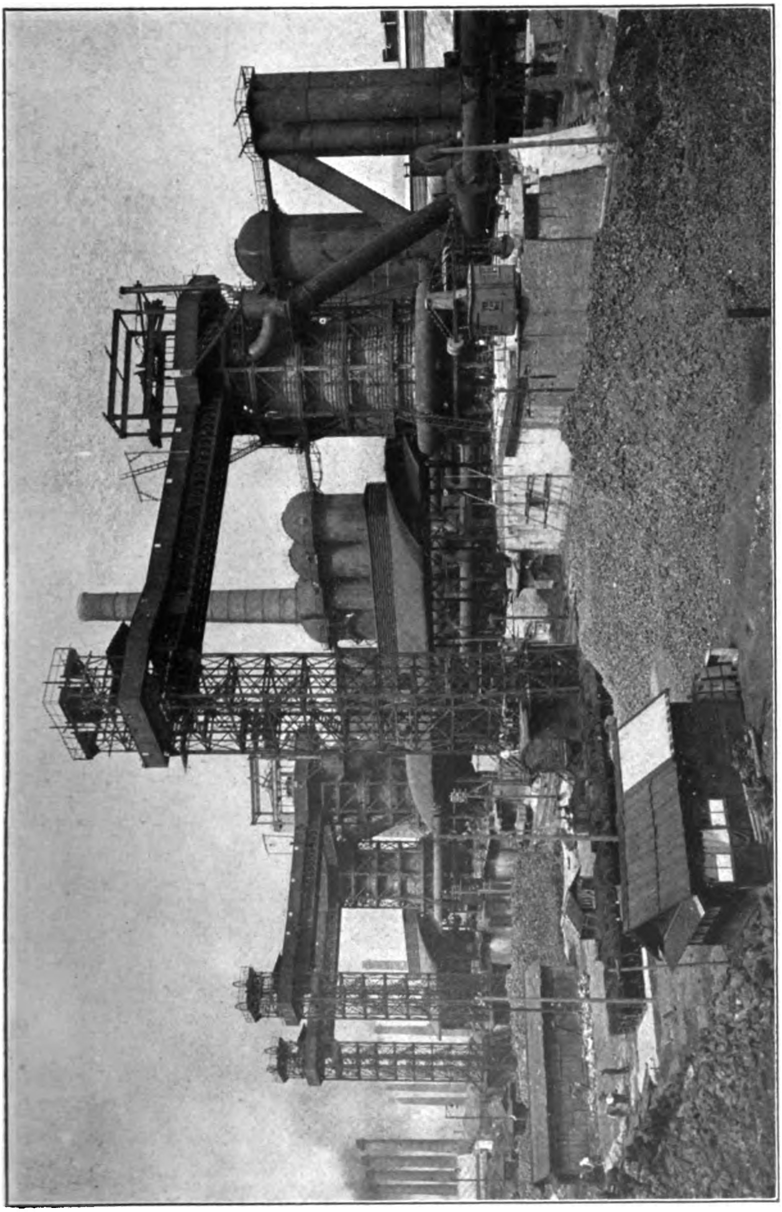


Fig. 8.—The Imperial Steel-Works, Kyūshū.

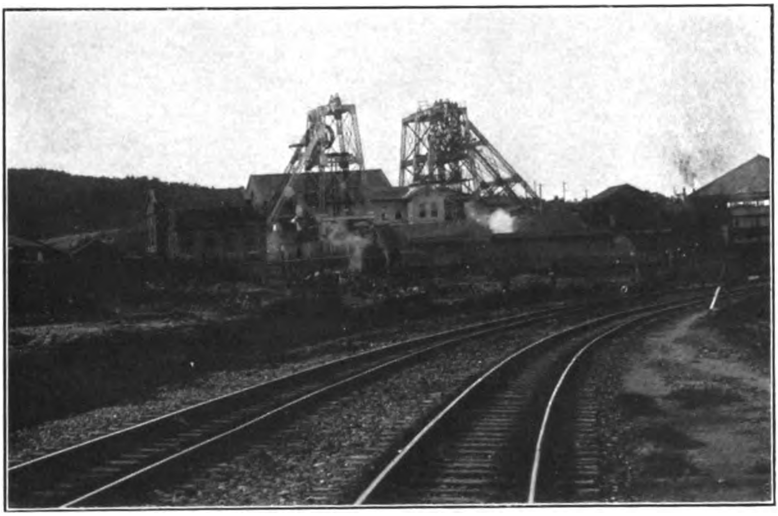


FIG. 9.—THE MANDA SHAFT, MIIKE COLLIERY.

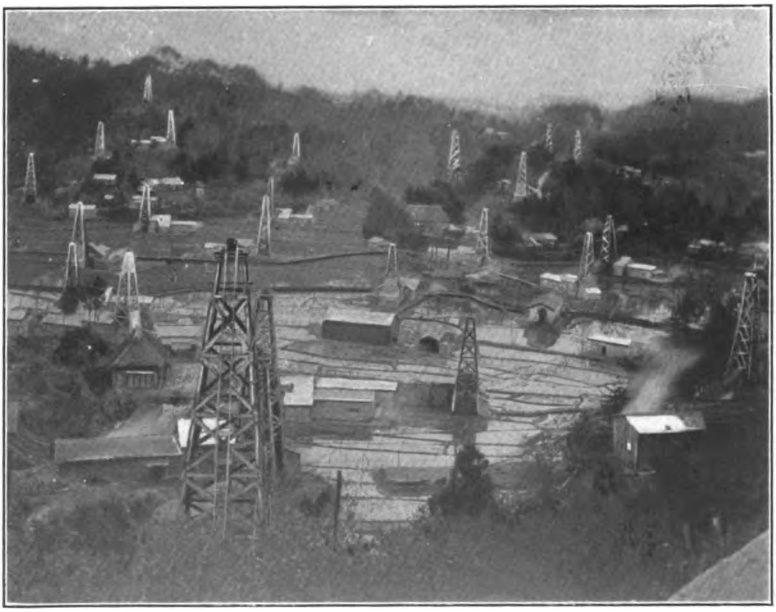


FIG. 10.—THE NISHIYAMA OIL-FIELD, ECHIGO.

II.—After the Restoration.

1. *Before the Japan–China War (from* 1867 *to* 1893).—Before the Restoration of 1867, the mining and metallurgical arts in Japan had reached the highest development which could be attained without the aid of mechanical contrivances—the only source of power available in that period having been manual labor. The condition was identical with that of Europe, 300 years ago. If in those days a further progress had been desired, it would have been turned towards a new direction, based on systematic science and refined economy.

The Restoration wrought in every direction throughout Japan, the greatest change in accordance with the requirement of the times. It was no wonder that the new government took every opportunity to encourage the mining industry. As the commencement of this policy, an act was issued in February, 1872, by which the Bureau of Mines was established in Osaka, which was formerly called the Osaka Copper-office, and which became the embryo of the present Bureau of Mines, Tokyo. A mining-law, *Nippon Kōhō*, was issued in January, 1873, according to which, whoever wanted to work a mine, had first to make application to the local office. If the people in that province did not lodge any complaint, the central government issued instructions to the local government to grant permission to work the mine during a certain term.

In order to lead the mining industry into a new trend, fresh sources of knowlege were sought in the Occident. At that time, the government took some of the larger mines under its control, and also supplied to them the knowledge and capital which they required. For this purpose, the Ikunos silver- and copper-mine, in December, 1868, and then the Sado gold-mine, the Kosaka silver-mine, the collieries of Takashima and Miike, the Okudzu gold-mine, the iron-mines of Kamaishi and Nakakosaka, the Innai silver-mine, and the Ani copper-mine—ten in all—were selected as the government mines successively. In 1870 the Bureau of Mines engaged Baron von Richthofen, a German geologist, to prospect mines and to promote the establishment of a mining-school. Our government utilized most wisely the services of mining engineers, civil engineers, geologists, and other instructors, and even of miners

from England, America, France, and Germany, numbering in all 78 men, for the reformation of various industries in Japan. The foreign engineers were distributed to the government mines to direct the working, and in order to prosecute their designs, the government invested the required capital, and thus gave practical examples of mining, which aroused the people from their long sleep in this industry. Not only were the mines supplied with capital, but also the people learned the foreign arts, which were finally propagated in all the mines throughout Japan. Among the eminent mining engineers now engaged in the business, there are not a few who were directly educated by these Occidental engineers.

The government mines having undergone much improvement in consequence of the policy above mentioned, the government afterwards thought it high time to hand over the mines to private enterprise. Accordingly, in 1885, all the government mines, except the Miike colliery, the Ikuno, and the Sado mines, were disposed of to the people. At the same time the engineers who had been educated by the foreign engineers, took the place of the latter in working the mines. Afterwards the Miike colliery was sold to a private operator in 1888 A.D., and the Sado and Ikuno mines were assigned to the Bureau of the Imperial Estate in the following year, leaving the Shinbaru and Gotoku collieries, worked for the navy, as the only mines under government control. In short, the unremitting efforts of the government in the industrial sphere have been modified from time to time, as the conditions required.

The progress of society did not allow the continuation of such an arbitrary system as the mining-law, *Nippon Kōhō*, already mentioned, which was calculated to impair seriously the advance of the mining industry. In 1890 the law was amended; and the new regulation, *Kōgyō Jōrei*, was issued two years later. The concession system, which distinctly established the right of permanent working, introduced a sound development of the mining industry in Japan.

The government did not forget the necessity of technical education. In September, 1870, it laid a base of mining education by the erection of the Mining School, *Kōgakuryō*, at the instance of Oshima Takatō. Afterwards it was changed to the Engineering School, to teach not only mining, but all other

branches of engineering, by foreign instructors. In January, 1877, the courses of the school were raised, and the name was changed to the Engineering College. In September of that year other courses of lectures on mining and metallurgy were commenced in the Science Department, Tokyo College. Both were included in 1886 in the Tokyo Imperial University.

The Progress of Mining Practice.

Gunpowder was used for blasting in the Yūrrapu mine, Hokkaidō, in 1862, as before mentioned, and the practice was immediately followed by the Sado mine discontinuing the old means of drilling and fire-setting, and in the year of the Restoration, 1868, the Ikuno mine adopted also the blasting method. During the 18 years between 1868 and 1885 there was much activity in the introduction of new Occidental technical knowledge in several departments of mining. The laying of rails both underground and overground, the sinking of shafts and the driving of levels, the introduction of stoping systems (including the pillar and long-wall systems for coal), methods of timbering, the deep boring for exploration, the application of horse-, water-, and steam-power, the use of winding-engines, pumps, and ventilators, ore-breakers, dressing-apparatus, and reverberatory furnaces, the methods of amalgamation and lixiviation of gold-, silver-, and copper-ores, the methods of assaying, and the method of underground surveying and mapping—are the principal items of improvements introduced from foreign countries.

From 1885 to 1890, rock-drills, dynamite, and high explosives came into extensive use, while effective up-to-date machines were adopted in rapid succession—such as aerial rope-tramways, Huntington mills, Frue vanners, and other new dressing-machines, together with Piltz furnaces, water-jacket furnaces, steam boilers of new types, water-turbines, electric deposition, etc. The adoption of electricity generated by water-power at the Ashio copper-mine, in 1889, called the attention of mining-operators to the great technical and economical advantages of this agency, and greatly accelerated the progress of the mining practice. In 1893 the Bessemer process for copper was introduced, which has produced a striking effect on the copper industry.

The iron-metallurgy of Japan has very ancient records to

show. In the districts of Chūgoku, pig- and wrought-iron and steel were prepared from magnetic sand to the satisfaction of all the domestic demands. In 1874 the government started iron-smelting works after the most up-to-date method in the Kamaishi iron-mine; but the enterprise proved, unfortunately, to be a failure. Ever since that time charcoal pig-iron has been made in Kamaishi, Hitokabe, and the environs of Morioka city. The iron necessary to supply the deficiency of the domestic production has been imported from abroad.

In the coal-fields of Kyūshū, which furnish at present 65 per cent. of the total output of coal in Japan, the Shakano-o colliery led others into the setting up of boilers in 1881. In Hokkaidō, coal was first worked in 1883, under Benjamin Smith Lyman, an American geologist. During the period under consideration, the domestic consumption of coal was quite insignificant. Railways were laid in 1880 between the collieries in Hokkaidō and the harbor of Otaru, and in 1891 the mining-railways of Chikuhō introduced a new feature in coal-mining. After the introduction of American rope-drilling into the Amaze oil field in Echigo, the oil industry achieved positive economical successes.

2. *After the Japan-China War* (*from* 1894 *to* 1908 A.D.).—In 1894 arose the Japan-China war, which ended in the victory of Japan. Subsequently, with the sudden uprising of various branches of industry, a new foundation of mining activity was soundly laid.

In 1897, the cyanide process was introduced into the gold-mines in Satsuma, and this method has rapidly been propagated throughout all the gold-mines of Japan. Mechanical roasting was introduced at the Ashio copper-mine in 1900; and in the same year the Kosaka mine, adapting pyritic smelting of its ores, took its place as a leading producer of copper, gold, and silver, instead of being only the largest silver-mine. These steps have practically revolutionized copper-ore smelting in Japan. Copper blast-furnaces have been gradually enlarged. For instance, the furnace at the Kosaka mine, 60 by 3.3 ft. in size, was the largest in the world when it was erected in 1907, and afterwards (June, 1908), in the Kano copper-mine, a furnace 65.5 by 3.3 ft. in the section at the level of the tuyeres was built. The most noteworthy recent events in the mining world are

the open working of the massive ore-deposits in the Kosaka copper-mine; the utilization of zinc-blende, by means of magnetic separation, in the Kamioka and the Kano mines; the adoption of lime-roasting in the copper-mines of Hitachi, Ashio, Kamioka, Osaruzawa, Kosaka, Besshi, etc., and, finally, the practice of the flotation process for zinc-ores in the Kamioka mine.

Cupriferous pyrites have begun to be used as sulphur-ore, the residue being utilized as flux in the smelting of acidic copper-ores. The demand for the pyritic ores grew larger with the increased use of phosphate fertilizers, in or about 1900; custom-smelters on a small scale appeared after 1890, and 12 independent smelting-works were once worked in and about the Inland Sea, when the sulphuric acid and the phosphate fertilizer manufacturing industry became more prosperous than ever. In fact, the mines of Kosaka, Hitachi, Ikuno, Yoshioka, and others have actually begun to purchase ores. Thus it will be seen that the metallic mineral industry has been gradually and vigorously developed upon an independent foundation.

After the Japan-China war, popular opinion demanded the establishment of iron-works by the government. To meet this necessity, the Imperial Steel Works, in Kyūshū, were opened in 1901. Their capacity was intended to be one-half of the annual demand, which was estimated to be 120,000 long tons. Since then, the plant has been gradually enlarged to 150,000 long tons at present; one blast-furnace has been erected at the Sennin iron-mine, for the manufacture of charcoal-pig; and at the Kamaishi mine, the plant has been enlarged, and Siemens-Martin furnaces have been built. In 1909, at the harbor of Mororan, an experimental blast-furnace was blown in. Another steel-foundry is now being built in the same place, under the co-operative efforts of the Hokkaidō Colliery & Steamship Co. and the two firms of Armstrong and Vickers & Sons.

In 1898 coal was first exported to a certain place on the Chinese coast. The collieries of Kyūshū were gradually deepened, and many of the slopes in the district attained the depth of several thousand feet. The extra cost of timbering, transportation, and drainage, rendered slopes uneconomical, and at the beginning of 1900, a shaft 700 ft. deep was completed in the Shin-nyu colliery, and in 1902, the famous Manda First Shaft,

896 ft. deep, was finished in the Miike colliery. New shafts 1,000 ft. deep are being sunk successively in the collieries of Ita and Futase. Those collieries have gradually adopted electric power, which took the place of steam-boilers in use. Since "special" pumps were first introduced in the colliery of Kyūshū, they have been adopted in general except in the Miike. Though these pumps are uneconomical, yet they satisfied their demand, because water is found in but a small quantity in all collieries in this region. However, since 1900, other economical pumps have been adopted, such as the Evans and other electric pumps. As regards the improvement of the pumping-apparatus, the Miike was always a leader, affording great benefits to other collieries, because it requires a supply of great pumping-power (about 25,000 h-p.) for regular operations and for experiments. Together with this technical progress, the amalgamation of mining concessions and the enlargement of working-plants have also induced the rapid advancement and the success of the coal industry since 1900.

The progress of mining industry called for the reformation of the mining-law, *Kōgyō Jōrei.* Hence, in 1905, the mining-law *Kōgyō-Ho*, now in force, was promulgated, but it was only a rearrangement, without essential alterations, of the *Kōgyō Jōrei.* As to technical education, though the Tōkyō University supplied a considerable number of graduates, the demand of the mines was far from being satisfied, and the want was most keenly felt. So the government, as well as the people, have recently endeavored to establish educational institutions. The result has been the opening of the Kyōto Imperial University and the three government technical high-schools in Osaka, Kumamoto, and Sendai. Another mining high-school is now being built in the city of Akita by the joint efforts of the mine-owners and the government, besides one erected near Wakamatsu in Kyūshū by the private enterprise of K. Yasukawa. Lately the courses of lectures on mining and metallurgy have been opened in the Waseda University, founded by Count Okuma, and the Kyūshū Imperial University at the city of Fukuoka. The Kōshu-Gakkō or Foreman's School in Tōkyō, the Technical School of Fukuoka Prefecture, and others are worthy of note. The first, being the oldest school of this class, has the largest number of graduates. Also, mines such as the

Miike colliery and others, where primary mining-education is given, have recently increased. Thus, in the future, a sufficient number of engineers will be supplied, and it is expected that those who are advanced in technical knowledge will be obtainable at pleasure, according to the demand.

In 1908, the motive-power utilized in all the Japanese mines and collieries amounted to 255,477 h-p. including both steam- and water-power; but it is a conspicuous fact that there was not a single boiler at the time of the Restoration (1867) and in 1890 the steam- and water-power did not exceed 5,300 h-p. In future, it is expected that electricity generated by water will be utilized extensively, so that the amount of the motive-power will show correspondingly a great increase.

From the short description given above, it will be seen that the mining industry before the Restoration was insignificant—the mineral products in 1874 were valued at £154,690. The output had increased in 1908 to £11,638,667. The development of the industry is shown in Tables I. to IV., and the production of principal mines in 1908 in Tables V. to VIII. The principal causes of this great prosperity are found in the introduction of the modern civilization of Europe and America, at the time of Restoration of the present *régime*, with wise judgment and prudent solution, and in the revival, under the power of administration and education, of the industrial genius of the early Japanese, which has thus been directed in fruitful activity.

In reporting the results of the judgment of the Fifth National Exhibition at Osaka in 1903, Prof. W. Watanabe, member of the jury, said:

"After all, the reason why the mining industry has made an incomparably rapid progress depends before any thing else upon the wise administration of the government, to which may be added the following reasons:

"(1) The establishment of typical mining-works by the government, and the introduction of foreign technics; (2) the introduction of education regarding the mining industry with satisfactory results; (3) the handing over of the government mines to private operation; (4) the publication of mining-laws to meet the development of the mining industry; (5) the application of electricity generated by water-power as motive-power in the mining industry."

TABLE I.—*Production of Gold, Silver, Copper, and Lead in Japan*, 1874 *to* 1908.

Year.	Gold.		Silver.		Copper.		Lead.	
	Troy Oz.	Value.	Troy Oz.	Value.	Long Tons.	Value.	Long Tons.	Value.
1874	3,129	£6,415.2	87,890	£10,820.4	2,078.5	£76,882.0	......	......
1875	5,598	11,436.2	224,842	27,609.2	2,363.1	87,179.2	......	......
1876	7,147	14,569.0	280,892	34,634.9	3,135.8	115,907.4	......	......
1877	11,264	23,376.8	355,126	44,860.7	3,884.2	143,237.2	......	......
1878	8,764	18,143.2	318,017	40,300.4	4,194.1	155,630.6	......	......
1879	8,402	25,991.7	292,172	52.631.4	4,562.4	218,934.9	......	......
1880	9,925	37,486.1	332,406	78,277.7	4,600.8	270,196.7	......	......
1881	9,792	35,751.9	574,270	119,562.1	4,701.4	259,329.3	......	......
1882	8,736	23,618.7	558,783	95,496.1	5,533.4	258,981.3	......	......
1883	9,669	22,405.9	775,840	74.563.8	6,674.8	281,508.8	......	......
1884	8,830	21,424.6	736,321	86,974.6	8,758.3	245,296.6	......	......
1885	8,811	21,997.1	766,360	97,141.9	10,386.4	229,149.2	......	......
1886	14,937	31,441.1	1,083,057	117,814.7	9,630.9	233,909.0	......	......
1887	16,739	36,740 1	1,024,608	144,994.9	10,901.1	241,949.9	......	......
1888	20,230	43,728.2	1,374,113	147,655.2	13,179.3	475,862.8	......	......
1889	24,709	47,163.7	1,381,497	177,858.5	16,015.5	426,169.6	......	......
1890	23,362	49,410 6	1,699,029	209,341.6	17,849.5	509,708.6	......	
1891	23,217	52,954.0	1,886,324	229,985.5	18,754.6	504,376.6	791	£7,860.5
1892	22,523	55,905.1	1,936,753	243,682.2	20,423.5	524,040.7	892	7,426.1
1893	23,676	61,130.6	2,226,825	273,714.8	17,750.8	492,413.3	1,089	10,273.0
1894	25,260	80,116.2	2,328,131	285,453.6	19,622.5	568,148.2	1,395	15,589.5
1895	40,898	106,213.3	2,323,673	254,470.8	18,834.4	720,484.1	1,904	21,247.7
1896	30,928	97,103.2	2,068,864	286,574.1	19,784.8	634,025.4	1,913	20,514.4
1897	33,617	120,758.4	1,745,657	191,116.0	20,091.5	783,494.0	754	8,391.4
1898	39,303	142,939.1	1,943,362	215,984.4	20,715.9	886,711.9	1,667	21,261.9
1899	58,654	238,003.8	1,805,879	215,648.1	23,920.6	1,456,549.5	1,946	28,495.8
1900	80,596	325,124.9	1,890,716	233,655.8	24,938.9	1,628,238.8	1,839	32,552.8
1901	101,683	446,846.1	1,760,158	211,681.9	26,990.0	1,625,244.2	1,765	24,640.9
1902	143,993	565,394.4	1,852,067	193,675.2	29,144.0	1,374,294.1	1,610	18,911.1
1903	139,628	554,027.7	1,884,162	196,603.3	32,111.0	1,720,213.9	1,689	20,416.8
1904	132,814	545,686.8	1,977,756	228,724.2	31,653.0	1,797,925.5	1,765	23,623.4
1905	148,645	612,903.3	2,678,511	330,983.9	34,975.0	2,366,333.1	2,224	32,189.6
1906	132,986	549,820.6	2,543,774	345,621.5	37,950.0	3,007,992.6	2,754	49,690.9
1907	134,153	554,740.7	3,091,022	424,601.8	39,556.0	3,372,887.7	3,015	56,863.6
1908	168,883	698,752.4	3,993,061	451,168.5	41,113.0	2.301,184.9	2,849	40,512.3

TABLE II.—*Production of Tin, Iron, Pyrite, and Antimony in Japan*, 1874 *to* 1908.

Year.	Tin.		Iron.		Iron Pyrite.		Antimony.	
	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.
1874	......	......	4,817	8,019.8	......	......	......	......
1875	......	......	3,388	5,646.8	......	......	......	......
1876	......	......	6,346	10,591.5	......	......	34	193.9
1877	......	......	8,087	13,497.4	......	......	19	106.4
1878	.....	......	10,006	16,701.7	......	......	16	974.9
1879	......	......	12,824	33,404.4	......	......	639	3,668.9
1880	......	......	15,889	47,885.2	......	......	494	2,836.5
1881	......	......	15,869	53,846.1	......	......	382	2,194.6
1882	......	......	12,070	38,261.3	......	......	2,482	16,312.5
1888	......	......	14,600	33,881.9	......	......	2,338	13,811.9
1884	......	......	11,672	27,134.2	......	.....	1,446	12,558.1
1885	......	......	6,671	24,843.2	......	......	2,605	25,152.8
1886	......	......	13,546	21,766.8	......	......	2,842	19,621.7
1887	......	......	15,027	31,068.4	......	......	1,516	14,448.1
1888	......	......	18,003	43,164.1	......	......	1,232	17,509.9
1889	......	......	20,830	51,966.2	......	......	1,730	32,111.5
1890	......	......	22,059	50,453.9	......	......	2,055	43,491.6
1891	43	229.2	17,038	28,879.5	240	61.2	1,629	31,034.1
1892	40	2,395.6	19,442	41,774.7	2,220	1,365.0	1,317	18,858.7
1893	37	2,312.3	17,190	40,462.0	410	324.8	1,566	20,878.5
1894	38	2,494.8	19,225	57,169.6	5,045	1,088.9	1,588	24,885.7
1895	47	3,093.6	25,339	90,678.3	6,192	1,072.0	1,648	28,541.2
1886	46	2,650.9	26,762	96,215.1	8,700	908.9	1,315	23,028.4
1897	46	2,652.8	27,548	100,205.4	7,466	3,221.4	1,146	20,403.1
1898	42	2,271.4	28,238	83,116.7	8,543	2,788.1	1,211	21,381.4
1999	18	1,712.4	22,332	91,664.7	8,200	1,116.8	921	22,014.7
1900	12	1,181.1	24,468	95,528.6	15,826	2,586.6	420	12,184.8
1901	14	1,374.9	68,959	294,886.9	17,219	2,778.2	359	18,481.4
1902	18	1,861.0	63,462	296,168.3	18,190	2,824.2	603	13,451.9
1903	19	1,988.3	74,918	349,771.8	15,782	2,579.4	574	10,782.8
1904	24	2,607.3	74,310	338,328.0	24,363	5,308.9	417	8,374.4
1905	25	3,315.7	137,748	721,500.8	25,032	7,500.3	280	9,178.4
1906	23	4,089.1	181,608	846,495.7	35,212	9,399.5	296	22,862.6
1907	31	5,018.5	190,577	988,650.7	54,987	20,294.7	243	14,383.4
1908	25	3,507.6	183,110	917,003.5	33,156	17,145.9	194	5,347.8

Table III.—*Production of Zinc-Ore, Manganese-Ore, Phosphate-Rock, and Sulphur in Japan,* 1874 *to* 1908.

Year.	Zinc-Ore.		Manganese-Ore.		Phosphate-Rock.		Sulphur.	
	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.
1874	......	......	......	......	......	......	569	£1,042.4
1875	......	......	......	......	......	......	574	1,051.4
1876	......	......	......	......	......	......	1,368	2,508.0
1877	......	......	......	......	......	......	1,297	2,377.6
1878	......	......	......	......	......	......	2,107	3,861.8
1879	......	......	.....	......	......	......	1,714	3,115.9
1880	......	......	......	......	......	......	1,166	2,139.9
1881	......	......	......	......	......	......	684	1,253.2
1882	......	......	.... .	......	......	......	3,331	4,481.2
1883	......	......	......	......	......	......	6,794	14,042.1
1884	......	......	......	......	......	......	4,189	15,990.9
1885	......	......	......	......	......	......	4,846	8,374.0
1886	......	......	......	......	......	......	6,312	9,852.9
1887	......	......	......	......	......	......	10,555	14,433.8
1888	......	......	.....	......	......	......	19,199	21,816.6
1889	......	......	......	......	......	......	16,527	29,369.1
1890	......	......	......	......	......	......	21,184	30,158.4
1891	......	......	3,156	£6,053.2	......	......	21,469	34,000.4
1892	......	......	4,913	1,873.8	......	......	20,055	41,245.2
1893	......	......	3,958	11,593.6	......	.... .	23,387	44,079.8
1894	......	......	13,064	8,391.0	......	......	18,360	30,206.1
1895	......	......	16,753	7,820.1	......	......	15,204	24,208.2
1896	......	......	17,559	12.526.9	......	......	12,255	25,113.7
1897	......	......	15,097	8,764.2	......	......	13,297	33,593.1
1898	......	......	11,256	8,029.1	......	......	10,644	29,497.8
1899	......	......	11,098	7,935.2	......	......	10.585	28,865.0
1900	......	......	15,498	16,308.0	......	......	14,858	33,515.6
1901	......	......	15,928	10,846.4	......	......	17,806	43,091.8
1902	......	......	10,638	6,701.0	193	£120.1	19,502	48,285.8
1903	......	......	5,489	3,737.8	188	120.2	24,402	61,830.8
1904	......	......	4,236	3,603.9	13	16.2	28,141	65,116.8
1905	......	......	13,723	8,176.6	1,494	1,134.2	25,286	60.306.6
1906	13,998	£20,824.1	12,572	8,282.7	3,090	1,842.1	28,521	62.974.1
1907	19,358	32,154.8	20,153	14,410.1	1,698	740.4	33,917	81,728.4
1908	18,010	30,877.5	10,897	8.259.4	728	730.2	34,645	79,269.1

Table IV.—*Production of Graphite, Coal, Petroleum, etc., in Japan,* 1874 *to* 1908.

Year.	Graphite.		Coal.		Petroleum.		Other Products.	Total Mineral Production. Value.
	Long Tons.	Value.	Long Tons.	Value.	U. S. Barrels.	Value.	Value.	
1874	......	......	204,864	£49,065.1	3.499	£2,444.6	......	£154,689.5
1875	......	......	558,288	114,838.8	5,489	3,835.2	......	251,596.8
1876	......	.....	587,011	111,998.5	9,267	6,276.8	......	296,680.0
1877	......	......	491,835	103,649.0	12,628	8,030.5	......	339,135.6
1878	......	......	669,806	146,797.5	21,500	15,022.7	......	397,432.8
1879	......	......	845,057	161,395.3	28,199	19,703.5	......	518,846.0
1880	.....	......	865,201	212,270.5	30,651	21,417.2	......	672,509.8
1881	......	......	911,720	225,233.3	20,138	14,070.5	......	711,241.0
1882	......	......	915,676	265,982.2	23,311	17,642.5	£12,550.7	733,326.5
1883	......	......	987,818	236,385.1	24,613	10,666.8	10,597.3	647,863.6
1884	......	......	1,123,330	242,170.3	7,063	10,796.4	7,307.2	669,652.7
1885	......	......	1,274,775	266,238.5	8,324	9,849.6	7,172.7	689,819.0
1886	......	......	1,354,190	280,360.3	15,326	13,691.1	11,515.4	739,943.0
1887	......	......	1,720,909	307,701.0	10,034	12,629.8	16,027.6	819,993.1
1888	......	......	1,893,970	409,060.2	45,006	13,860.2	17,928.6	1,190,585.8
1889	......	......	2,353,849	541,723 4	63,490	25,097.7	15,035.8	1,346,495.5
1890	......	......	2,589,997	623,366.2	61,817	22.147.8	15,151.0	1,553,309.7
1891	241	£915.5	3,129,581	657,399.7	63.618	20,702.9	1,452.2	1,575,904.5
1892	59	348.6	3,129,409	606,870.5	82,833	22,530.2	35.3	1,567,851.7
1893	27	241.6	3,271,244	625,744.8	106,983	20,649.3	1,155.8	1,604,974.2
1894	1,066	2,515.7	4,214,253	1,020,511.1	172,711	26,163.5	1,701.5	2,124,435.4
1895	428	781.0	4,718,914	1,275,787.5	169,873	38,227.8	1,701.5	2,574,327.1
1896	210	2,594.8	4,946,568	1,187,423.3	236,819	35,160.7	2,004.8	2,425,844.6
1897	382	6,168.9	5,131,628	1,909,692.1	262,751	34,821.9	596.5	3,223,879.2
1898	339	6,238.6	6,640,468	2,709,954.7	319,015	34,896.2	314.6	4,165,330.9
1899	52	969.6	6,653,476	2,306,362.5	539,098	104,369.4	1,737.9	4,505,481.4
1900	92	2,385.5	7,362,891	2,474,326.5	871,740	194,201.3	2,139.2	5,053,924.5
1901	86	1,743.3	8,879,511	3,084,254.6	1,117,995	227,882.1	1,274.5	5,990,027.2
1902	95	1,984.2	9,656,295	3,255,718.7	997,543	207,784.0	475.8	5,987,649.8
1903	111	2,199.4	10,021,893	2,925,307.2	1,210,340	281,936.2	316.6	6,132,127.2
1904	212	3,708.8	10,649,026	2,947,678.7	1,220,744	278,060.6	271.8	6,249,036.2
1905	204	2,651.8	11,467,845	4,050,127.9	1,352,574	296,948.1	371.5	8,504,621.9
1906	138	2,444.9	12,892,721	6,348,445.7	1,571,367	317,901.1	867.8	11,599,555.0
1907	101	1,046.9	13,736,182	6,044,584.6	1,727,298	527,749.6	1,861.2	12,141,716.6
1908	147	1,726.3	14,761,476	6,416,698.4	1,872,592	658,598.4	7,885.0	11,638,667.2

TABLE V.—*Production of Principal Mines in* 1908.

GOLD, SILVER, COPPER, AND LEAD.

Mines.	Prefectures.	Concessionaires.	Output.					No. of Laborers.
			Gold.	Silver.	Copper.		Lead.	
					Metal.	Ore.		
			Troy Ounces.	Troy Ounces.	Long Tons.	Long Tons.	Long. Tons.	
Poropets	Hokkaidō	Oda Ryoji	6,559.2	6,629.5	69.0			267
Shiribeshi	Hokkaidō	Tokunaga Shigeyasu	1,033.2	14,787.1				149
Kosaka	Akita	Fujita & Co	10,490.8	1,110,707.2	7,086.2		372.2	7,642
Tsubaki	Akita	Takeda Kyōsaku		1,244,572.8	273.9			1,865
Ani	Akita	Furukawa Mining Co.		44,948.3	1,284.6			3,560
Osaruzawa	Akita	Mitsubishi & Co	412.7	25,219.0	1,358.4			1,502
Komaki	Akita	Mitsubishi & Co						119
Arakawa	Akita	Mitsubishi & Co			732.2			1,747
Hisan-ichi	Akita	Mitsubishi & Co		34,508.0	689.7			758
Furokura	Akita	Furukawa Mining Co.			578.5			734
Innai	Akita	Furukawa Mining Co.	967.9	94,757.9	152.7			347
Tokitō	Akita	Fujita & Co			279.0	4,078.3		375
Hanaoka	Akita	Ishida Kumakichi				4,203.2		90
Daiji	Akita	Fujita & Co			74.5			117
Matsuoka	Akita	Fujita & Co	365.9	11,150.8				270
Okuzu	Akita	Mitsubishi & Co	48.0	89.0		1,914.7		121
Midzusawa	Iwate	Furukawa Mining Co.			255.6			783
Kamaishi	Iwate	Tanaka Chōbei	2,013.4		47.5	3,288.1		4,555
Washinosu	Iwate	Tameda Buntarō	1,346.2	83.6				253
Oarazawa	Iwate	Saitō Tatsugorō			73.8			78
Unekura	Iwate	Satō Jirō			74.2			126
Shishiori	Miyagi	Tokunaga Shigeyasu	2,041.7	569.2				150
Nagamatsu	Yamagata	Furukawa Mining Co.		12,998.2	259.2			504
Ōtori	Yamagata	Furukawa Mining Co.		8,988.4	122.9			378
Karatoya	Yamagata	Karatoya Mining Co			1.4	429.8		101
Yoshino	Yamagata	Yokota Ichisaku and others				143.2		65
Kanō	Fukushima,	Kanō Mining Co	781.1	91,624.7	974.0			2,181
Handa	Fukushima,	Godai Riusaku	656.9	21,249.4				112
Yakuki	Fukushima,	Yakuki Mine Co			113.5			109
Sado	Niigata	Mitsubishi & Co	13,740.0	113,651.9	3.7			1,238
Kusakura	Niigata	Furukawa Mining Co.			237.7			489
Hirotani	Niigata	Furukawa Mining Co.			61.8			139
Ashio	Tochigi	Furukawa Mining Co.		75,082.4	6,972.4			7,274
Kobyaku	Tochigi	Kobyaku Mine Co			154.0			150
Hitachi	Ibaraki	Kuhara Fusanosuke	1,558.4	30,615.5	1,871.5			1,013
Takara	Yamanashi	Mitsubishi & Co			109.7			95
Kune	Shizuoka	Furukawa Mining Co.				43,018.2		438
Ōmatsuyama	Shizuoka	Kurotaki Chōjiro	512.4	3,608.9				44
Kamioka	Gifu	Mitsui Mining Co	246.4	169,529.8	38.9		2,129.8	2,251
Hiragane	Gifu	Yokoyama Takaoki		38,996.3	509.7			824
Takane	Gifu	Asada Sanemon		14,168.3	141.6			227
Hatasa	Gifu	Okunō Mining Co		25,327.9	44.7			182
Ogoya	Ishikawa	Yokoyama Takatoshi			685.4			1,143
Yūsenji	Ishikawa	Yoshinotani Coal Mine Co			610.5			880
Kuratani	Ishikawa	Kuratani Mine Co	2,415.7	38,585.1	2.5		184.0	352
Kanahira	Ishikawa	Murata Sukematsu	1,066.4					424
Ate	Ishikawa	Moriyama Saichi			60.4			160
Togi	Ishikawa	Kinoshita Ryō and others	697.0	624.5				138
Omodani	Fukui	Mitsubishi & Co	7.2	28,689.1	182.8			360
Takamasa	Shiga	Osaka Mining Co		848.3	9.9			23
Iimori	Wakayama	Nakae Tanezo			75.3			70
Kyōsei	Nara	Tanaka Ginnosuke				4,875.6		180
Ikuno	Hyōgo	Mitsubishi & Co	3,881.0	211,865.5	1,152,1	4,215.1		1,949
Kanasaka	Hyōgo	Hayashi Heizō and others			37.9			79
Karatani-Kawakami	Hyōgo	Tsuchiya Minekichi		3,072.0	27.9			78
Tada	Hyōgo	Hori Tōjurō		4,656.2	18.7		0.5	
Ōmori	Shimane	Fujita & Co	1,689.6	96,153.6	314.2		4.1	675
Hōmanzan	Shimane	Hori Tōjurō			270.9			491
Sasagatani	Shimane	Hori Tōjurō		12,210.0	144.3			296
Dōgamaru	Shimane	Hori Tōjurō		9,504.0	56.7			166
Kuki	Shimane	Hori Tōjurō		20,291.6			102.5	105
Wanibuchi	Shimane	Wanibuchi Mining Co.			11.1	1,254.2		111
Yoshioka	Okayama	Mitsubishi & Co	138.8	60,590.4	778.5			1,273
Obiye	Okayama	Sakamoto & Co			736.4			813

TABLE V.—*Production of Principal Mines in* 1908.—*Continued.*

GOLD, SILVER, COPPER, AND LEAD.—Continued.

Mines.	Prefectures.	Concessionaires.	Output.					No. of Laborers.
			Gold.	Silver.	Copper.		Lead.	
					Metal.	Ore.		
			Troy Ounces.	Troy Ounces.	Long Tons.	Long Tons.	Long Tons.	
Mihara	Okayama	Utsunomiya Mining Co.				1,616.8		177
Kokusei	Okayama	Suzuki Ekiji			116.5	273.7		68
Konjō	Okayama	Sakata Mitsugi		8,559.9	41.9			182
Yamate	Okayama	Nomura Chōbei		2,380.3	31.1			66
Hisaki	Okayama	Kusakabe Toraji				287.2		50
Naganobori	Yamaguchi	Hori Tōjurō		6,693.1	115.2			176
Yakuōji	Yamaguchi	Kawabe Kurasaburo			53.2	871.1		191
Ōta	Yamaguchi	Ikuta Kunizo and others	5.3	2,389.4	64.1			133
Kitsunezuka	Yamaguchi	Kuwabara Masa and others			24.0			41
Mochibe	Tokushima	Shima Tokuzō				13,816.9		335
Higashiyama	Tokushima	Shima Tokuzō				2,963.3		2,687
Besshi	Ehime	Sumitomo Kichizaemon			5,173.3			3,477
Chihara	Ehime	Yabuuchi Senzō			170.5			165
Kanayama	Ehime	Mitsubishi & Co.				7,841.8		224
Nishinokawa	Ehime	Sumitomo Kichizaemon			87.8			161
Kuchō	Ehime	Seike Kumeichirō				1,988.2		195
Hirabaye	Ehime	Yamashita Kiichiro				4,136.0		75
Ōmine	Ehime	Shiraishi Watarō				1,956.0		123
Kajitani	Ehime	Shiraishi Watarō				2,097.1		73
Takaura	Ehime	Fujino Kamenosuke				1,615.1		35
Ōye	Ehime	Yano Sōzaburō				603.6		69
Nagamine	Ehime	Ueda Seiichi and others				305.1		26
Yano	Fukuoka	Yano Tomokichi	781.9	557.0				218
Taiōno	Ōita	Nangō Tokunosuke and others	3,099.4	2,035.2				226
Mizobe	Ōita	Kojima Tetsutarō	352.0	231.7				95
Iwaya	Kumamoto	Noda Kichibei			71.5			57
Hibira	Miyazaki	Naito Seikyo			870.3			1,021
Makimine	Miyazaki	Mitsubishi & Co.			541.6			866
Yamagano	Kagoshima	Shimazu Tadashige	12,167.5	26,735.3				2,219
Ushio	Kagoshima	Ushio Gold Mine Co.	8,932.6	3,426.6				477
Okuchi	Kagoshima	Iwatsuki Naohiko and others	4,766.8	2,115.2				424
Serigano	Kagoshima	Shimazu Tadashige	2.496.4	9,714.6				618
Nitabira	Kagoshima	Nagai Eikichi and others	1,325.5	2,847.7				198
Urushi	Kagoshima	Kamimura Ryōsuke and others	1,181.6	4,254.4				243
Fuke	Kagoshima	Asano Sōichirō	884.8	701.3				87
Bezaiten	Kagoshima	Hitaka Shōkō and others	179.3	24,271.6				98
Otani	Kagoshima	Satsunan Mining Co.	663.5	363.0				212
Kago	Kagoshima	Horinouchi Shōuemon	300.6	202.1				310
Hashima	Kagoshima	Horinouchi Shōuemon	145.7	693.1				17
Kinkaseki	Taiwan (Formosa)	Tauaka Chōbei	33,353.3	25,558.0	319.0			901
Botankō	Taiwan (Formosa)	Kimura Kintarō	9,193.7	3,873.1				479
Zuihō	Taiwan (Formosa)	Fujita & Co.	8,961.9	3,984.4				550

TABLE VI.—*Production of Principal Mines in* 1908.

ANTIMONY, IRON, MANGANESE-ORE AND SULPHUR.

Mines.	Prefectures.	Concessionaires.	Output. Antimony.	Output. Iron.	Output. Manganese-Ore.	Output. Sulphur.	No. of Laborers.
			Long Ton.	Long Tons.	Long Tons.	Long Tons.	
Oshino	Hokkaido	Oshino Kyō			7,455.9	9,457.8	469
Kobui	Hokkaido	Senshō Kōgyō Co.				5,574.9	259
Iwaonupuri	Hokkaido	Mitsui Mining Co.			1,455.5	3,002.0	286
Kumadomari	Hokkaido	Endō Kichihei				2,006.9	147
Shikabe	Hokkaido	Oshima Mining Co.				1,790.7	148
Uguisuzawa	Iwate	Satō Seibei and others				592.1	69
Kamaishi	Iwate	Tanaka Chōbei		86,662.4			4,555
Sennin	Iwate	Sennin Iron Foundry Co.		1,018.6 (ore) 2,885.7			958
Numajiri	Fukushima	Japanese Sulphur Co.				5,284.0	218
Ichinokawa	Ehime	Ichinokawa Mining Co.	158.3				259
Kujusan	Ōita	Hiromi Nisaburō				1,328.1	56
Kano	Yamaguchi	Sunohara Kumajirō and others	(ore) 259.2				65
Iwōjima	Kagoshima	Hiromi Nisaburō				607.5	76

TABLE VII.—*Production of Principal Petroleum Fields in* 1908.

Oil-Fields.	Prefectures.	Concessionaires.	Output* Barrels (42 Gallons)	No. of Laborers.
Koguchi	Niigata	Hōden Oil Co.	247,151.6	148
Niitsu	Niigata	Nippon Oil Co.	170,280.7	254
Kanatsu	Niigata	Hōden Oil Co.	129,825.0	77
Kanatsu	Niigata	Nakano Kanichi & others	86,018.2	95
Asahi	Niigata	Uchida Sansei	54,340.0	10
Asahi (19)	Niigata	Chūō Oil Co.	41,001.1	81
Kumazawa	Niigata	Hōden Oil Co.	31,421.6	82
Asahi (349)	Niigata	Chūō Oil Co.	21,349.0	86
Koguchi	Niigata	Fuji Oil Co.	19,629.5	13
Asahi 5th	Niigata	Nakano Chūtaro	17,008.0	43
Higashiyama	Niigata	Hōden Oil Co.	234,477.3	1,522
Urase	Niigata	Nippon Oil Co	49,886.4	54
Nagamine,	Niigata	Nippon Oil Co	331,920.5	706
Nagamine	Niigata	Hōden Oil Co	163,690.9	140
Kamada	Niigata	Hōden Oil Co.	47,129.5	55
Maki	Niigata	Nippon Oil Co.	31,812.5	289
Maki	Niigata	Hōden Oil Co.	31,343.2	160

* The output is calculated as crude oil.

TABLE VIII.—*Production of Principal Coal-Mines in* 1908.

Mines.	Prefectures.	Concessionaires.	Output.	No. of Laborers.
			Long Tons.	
Yūbari 1st	Hokkaido	Hokkaido Colliery & S. S. Co.	488,126.9	5,008
Soracpi	Hokkaido	Hokkaido Colliery & S. S. Co.	247,379.5	1,957
Shin-Yūbari	Hokkaido	Ishikari Coal Co. & others	165,390.8	1,583
Horonal	Hokkaido	Hokkaido Colliery & S. S. Co.	187,269.6	1,238
Yūbari 2nd	Hokkaido	Hokkaido Colliery & S. S. Co.	116,726.2	913
Ikushumpets	Hokkaido	Hokkaido Colliery & S. S. Co.	76,847.4	718
Pompets	Hokkaido	Nippon Kōgyō Co.	83,015.8	395
Uchinogō	Fukushima	Iwaki Coal Mine Co.	198,936.3	1,408
Onoda	Fukushima	Iwaki Coal Mine Co.	190,562.4	1,194
Iriyama	Fukushima	Iriyama Coal-Mining Co.	194,742.5	1,402
Yoshima	Fukushima	Yoshima Coal-Mining Co.	126,826.9	1,848
Ōjō	Fukushima	Ōjō Coal-Mining Co.	68,694.2	441
Sansei	Fukushima	Sansei Coal-Mining Co.	69,698.1	548
Ibaraki Saitan	Ibaraki	Ibaraki Coal-Mining Co.	69,783.6	598
Ibaraki Muentan	Ibaraki	Ibaraki Anthracite Mining Co.	59,042.2	622
Ōmine	Yamaguchi	Navy Department	96,885.7	974
Okinoyama	Yamaguchi	Watanabe Yūsaku	53,282.7	508
Kata	Yamaguchi	Noda Kichibei & others	58,826.8	149
Ōtsuji 4th	Fukuoka	Kaijima Tasuke	197,115.8	1,694
Ōtsuji	Fukuoka	Kaijima Tasuke	167,950.6	1,447
Miyoshi	Fukuoka	Miyoshi Tokumatsu	120,653.1	731
Iwasaki	Fukuoka	Iwasaki Kumekichi	85,417.7	486
Nakatsuru	Fukuoka	Itō Denyemon	57,656.4	371
Arate	Fukuoka	Itō Denyemon	54,450.9	558
Ōnoura	Fukuoka	Kaijima Tasuke	771,290.8	6,195
Shinnyu	Fukuoka	Mitsuaishi & Co.	426,621.0	4,945
Meiji	Fukuoka	Meidi Mining Co.	419,793.6	8,186
Shiogashira and Shakanoo	Fukuoka	Furukawa Mining Co.	373,198.0	2,705
Mitsui-hondo	Fukuoka	Mitsui Mining Co.	195,914.8	3,084
Gotoku Kaigun	Fukuoka	Navy Department	218,383.4	1,532
Koyanose (508)	Fukuoka	Egi Iwakichi	83,141.3	553
Koyanose (101)	Fukuoka	Egi Iwakichi	46,730.8	180
Namazuda	Fukuoka	Mitsubishi & Co.	271,836.0	2,207
Futase	Fukuoka	Government Steel Works	354,935.9	2,629
Yoshio	Fukuoka	Asō Takichi	243,306.0	1,792
Mitsui-yamano	Fukuoka	Mitsui Mining Co.	177,698.8	2,320
Tadakuma	Fukuoka	Sumitomo Kichizaemon	168,959.3	1,697
Mamena	Fukuoka	Asō Takichi	150,178.0	1,076
Aida	Fukuoka	Nakano Tokujiro & others	97,310.8	452
Kamiyamada	Fukuoka	Mitsubishi & Co.	93,850.4	1,021
Muta	Fukuoka	Itō Denyemon	91,832.8	758
Shimoyamada	Fukuoka	Furukawa Mining Co.	105,335.9	1,108
Hirayama	Fukuoka	Tajima Shinobu	32,720.7	537
Honami	Fukuoka	Ishida Osamu	16,120.2	166
Mitsui-tagawa	Fukuoka	Mitsui Mining Co.	536,290.0	4,460
Kanada	Fukuoka	Kanada Mining Co.	290,978.6	2,442
Ōtō	Fukuoka	Buzen Coal-Mining Co.	171,546.0	1,305
Akaike	Fukuoka	Meidi Mining Co.	172,952.2	1,444
Kōkoku	Fukuoka	Meidi Mining Co.	127,083.8	1,454
Hōjō	Fukuoka	Mitsubishi & Co.	96,648.4	1,188
Miyazaki-hōshu	Fukuoka	Miyazaki Giichi	106,002.3	929
Mineji	Fukuoka	Kashiwagi Kanpachiro	66,569.3	1,450
Honsoeda	Fukuoka	Masuya Hikosuke	60,447.8	853
Miyao	Fukuoka	Kurachi Jiichi	66,788.8	862
Soeka	Fukuoka	Abe Yasujirō	53,054.4	645
Kigyo-Komatsu-Gotōji	Fukuoka	Kurachi Shigehiko	64,765.3	556
Kaharu	Fukuoka	Kuwahara Masa	47,257.3	669
Tsubakuro	Fukuoka	Kaijima Tasuke	81,214.2	835
Shimbaru Kaigun	Fukuoka	Navy Department	81,921.1	1,318
Sasakuri	Fukuoka	Yonezawa Tokichi	60,593.2	354
Ueki	Fukuoka	Okada Sango	53,389.9	334
Miike	Fukuoka	Mitsui Mining Co.	1,513,388.6	9,976
Yoshinotani	Saga	Yoshinotani Coal-Mining Co.	251,770.7	3,160
Ōchi	Saga	Mitsubishi & Co.	161,468.0	2,476
Kishidake	Saga	Koga Seijiro & others	83,017.3	1,188
Akasakaguchi	Saga	Takatori Koreyoshi	124,462.9	1,547
Yunokibaru	Saga	Kaijima Tasuke	87,350.7	1,149
Kishima, 2nd	Saga	Tajima Shinobu	61,926.9	1,171
Kishima	Saga	Hieda Ichirōji & others	71,243.3	1,892
Takashima	Nagasaki	Mitsubishi & Co.	184,816.9	2,693
Matsushima	Nagasaki	Koga Shun-ichi	78,753.7	1,826
Matsura	Nagasaki	Matsura Coal-Mining Co.	80,719.2	486

No. 62 FEBRUARY 1912

Bulletin of the American Institute of Mining Engineers.

CONTENTS:

BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

No. 62 FEBRUARY 1912

PUBLISHED MONTHLY
BY THE AMERICAN INSTITUTE OF MINING ENGINEERS
at 124 to 128 N. Seventh St., Philadelphia, Pa.
Guy R. Overend, Publication Manager.

Editorial Office, 29 West 39th St., New York, N. Y.

JOSEPH STRUTHERS, Ph.D., Editor.

Cable address, "Aime," Western Union Telegraph Code.

Subscription (including postage), $10 per annum; to members of the Institute, public libraries, educational institutions and technical societies, $5 per annum.

Single copies (including postage), $1 each; to members of the Institute, public libraries, etc., 50 cents each.

Entered as second class matter, October 16, 1911, at the post office at Philadelphia, Pa., under the Act of March 3, 1879.

TABLE OF CONTENTS.

SECTION I. INSTITUTE ANNOUNCEMENTS.

SECTION II. TECHNICAL PAPERS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

All communications concerning the contents of this Bulletin should be addressed to JOSEPH STRUTHERS, Ph.D., Secretary and Editor, 29 W. 39th St., New York, N. Y.

OFFICERS.

For the year ending February, 1912.

COUNCIL.*

PRESIDENT OF THE COUNCIL.

CHARLES KIRCHHOFF..NEW YORK, N. Y.

(Term expires February, 1912.)

VICE-PRESIDENTS OF THE COUNCIL.

BENJAMIN B. LAWRENCE..NEW YORK, N. Y.
JOSEPH W. RICHARDS..SOUTH BETHLEHEM, PA.
ALBERT SAUVEUR..CAMBRIDGE, MASS.

(Term expires February, 1912.)

S. B. CHRISTY..BERKELEY, CAL.
W. A. LATHROP..PHILADELPHIA, PA.
GARDNER F. WILLIAMS..WASHINGTON, D. C.

(Term expires February, 1913.)

COUNCILORS.

KARL EILERS..NEW YORK, N. Y.
ALEX. C. HUMPHREYS..NEW YORK, N. Y.
W. G. MILLER..TORONTO, CANADA.

(Term expires February, 1912.)

ROBERT E. JENNINGS..NEW YORK, N. Y.
WILLIAM KELLY..VULCAN, MICH.
CHARLES F. RAND..NEW YORK, N. Y.

(Term expires February, 1913.)

A. E. CARLTON..CRIPPLE CREEK, COLO.
W. J. OLCOTT..DULUTH, MINN.
E. L. YOUNG..NEW YORK, N. Y.

(Term expires February, 1914.)

SECRETARY OF THE COUNCIL AND EDITOR.

JOSEPH STRUTHERS, 29 W. 39th St..NEW YORK, N. Y.

(Term expires February, 1912.)

SECRETARY EMERITUS OF THE COUNCIL.

R. W. RAYMOND..NEW YORK, N. Y.

CORPORATION.

JAMES GAYLEY, President; JAMES DOUGLAS, Vice-President;
FRANK LYMAN, Treasurer;
JOSEPH STRUTHERS, Secretary and Assistant Treasurer.

DIRECTORS.

THEODORE DWIGHT, ARTHUR L. WALKER, JOSEPH STRUTHERS.

(Term expires February, 1912.)

JAMES GAYLEY, CHARLES KIRCHHOFF, FRANK LYMAN.

(Term expires February, 1913.)

JAMES DOUGLAS, JAMES F. KEMP, ALBERT R. LEDOUX.

(Term expires February, 1914.)

---

* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation, and is therefore, for convenience, composed of members residing in New York.

COMMITTEES.

For the year ending February, 1912.

COUNCIL.

Membership:—Joseph Struthers, Benjamin B. Lawrence, Karl Eilers, Charles F. Rand, Edward L. Young.

Publications:—Joseph Struthers, *Chairman*, New York, N. Y.; David W. Brunton, Denver, Colo.; Samuel B. Christy, Berkeley, Cal.; Albert L. Colby, South Bethlehem, Pa.; Nathaniel H. Emmons, Copperhill, Tenn.; Charles H. Fulton, Rapid City, S. D.; James Gayley, New York, N. Y.; H. O. Hofman, Jamaica Plain, Mass.; Henry M. Howe, Bedford Hills, N. Y.; Walter R. Ingalls, New York, N. Y.; James F. Kemp, New York, N. Y.; R. V. Norris, Wilkes-Barre, Pa.; Edward D. Peters, Dorchester, Mass.; Rossiter W. Raymond, New York, N. Y.; Joseph W. Richards, South Bethlehem, Pa.; Robert H. Richards, Boston, Mass.; Albert Sauveur, Cambridge, Mass.; Henry L. Smyth, Watertown, Mass.; Arthur L. Walker, New York, N. Y.

CORPORATION.

Finance:—James Douglas, Albert R. Ledoux, Theodore Dwight.

Library:—Joseph Struthers, James F. Kemp, Arthur L. Walker.

Land Fund:—James Douglas; Theodore Dwight, *Treasurer;* T. F. Cole, Anton Eilers, James Gayley, John Hays Hammond, Charles Kirchhoff, Albert R. Ledoux, Frank Lyman.

INSTITUTE REPRESENTATIVES.

United Engineering Society Trustees:—Eben E. Olcott (1912), Joseph Struthers (1913), Theodore Dwight (1914).

Joint Conference Committee of the Four National Engineering Societies:—Charles Kirchhoff, Joseph Struthers.

John Fritz Medal Board of Award:—E. Gybbon Spilsbury (1913), R. V. Norris (1914), Charles Kirchhoff (1915), J. F. Kemp (1916).

American Association for the Advancement of Science:—H. O. Hofman, Boston, Mass.; John D. Irving, New Haven, Conn.

Eighth International Congress of Applied Chemistry, New York, September, 1912:—William L. Saunders, New York, N. Y.; George C. Stone, New York, N. Y.

International Association for Testing Materials Congress, Chicago, September, 1912:—Robert Forsyth, Chicago, Ill.

Committee No. 24, International Association for Testing Materials:—Henry D. Hibbard, Plainfield, N. J.

International Engineering Congress, San Francisco, 1915:—Samue B. Christy, William C. Ralston, Edwin T. Blake.

Canadian Mining Institute, Toronto, Mar. 6, 7, 8, 1912:—John Birkinbine, H. M. Chance, C. R. Corning, James Douglas, Theodore Dwight, W. E. C. Eustis, J. R. Finlay, F. Lynwood Garrison, W. R. Ingalls, William Kelly, James F. Kemp, Benjamin B. Lawrence, Albert R. Ledoux, Ambrose Monell, Henry S. Munroe, R. V. Norris, Edward W. Parker, Robert H. Richards, E. Gybbon Spilsbury, H. H. Stoek, Joseph Struthers.

CONSULTING ATTORNEYS.

Blair & Rudd, New York, N. Y.

INSTITUTE ANNOUNCEMENTS.

The New York Meeting.

As already published in announcement No. 3, sent from the Institute office under date of Jan. 29, 1912, the 102d meeting of the Institute for the reading and discussion of professional papers will be held in New York City, beginning Monday evening, Feb. 19, 1912. Headquarters will be at the Institute office, in the Engineering Societies Building, 29 West 39th Street, where a Bureau of Information, in charge of Mr. George Buckman, Office Manager of the Institute, will be maintained. The sessions will be held in one of the assembly-rooms of the building. Special reception committees have been appointed for each day's proceedings.

The arrangements of the meeting, apart from the technical sessions, are in the hands of the New York Local Section, the Executive Committee of which is Mr. Benjamin B. Lawrence, *Chairman;* Dr. James Douglas, *Vice-Chairman;* Mr. Bradley Stoughton, *Secretary-Treasurer;* Mr. C. P. Perin, and Dr. George F. Kunz. All inquiries concerning local matters, except those referring to papers and discussions for the technical sessions, should be addressed to Mr. Bradley Stoughton, 165 Broadway, New York, N. Y. The control of the papers and discussions will be exercised by the President and the Secretary of the Council, as usual.

No special reduction of railroad-fares for attendance at this meeting is practicable, nor have any hotel accommodations been reserved for visiting members, who will make individual arrangements in these respects.

Details of the technical sessions of the meeting will be given in the program of the Local Committee, which will be furnished to each member or guest on registration at Institute Headquarters. Members wishing to visit during the week of the meeting any industrial plant or work in New York City or vicinity will be assisted to do so by means of suitable introductions and guidance, upon timely notice given by them in advance to Mr. George Buckman, 29 West 39th Street, New York City.

The following provisional program has been arranged, subject to change by the Local Committee.

Monday, Feb. 19, 1912.—8.15 p. m. Informal social meeting and smoker at Institute Headquarters, including addresses on Institute matters by the President and the President-elect.

Tuesday, Feb. 20, 1912.—10.00 a. m. Annual Business Meeting.

12.30 p. m. Luncheon at the Engineering Societies Building.

2.00 p. m. Technical session, at which will be presented and discussed papers on "Fine-Ore Sintering," "Electro-Static Ore-Separation," and "Roll Crushing."

6.30 p.m. Reception and banquet at the Hotel Plaza, 59th Street and Fifth Avenue, New York City. Committee: James Gayley, *Chairman;* Albert R. Ledoux, D. M. Riordan, Theodore Dwight, and Thomas Robins.

Wednesday, Feb. 21, 1912.—10.00 a. m. Technical Session.
12.30 p. m. Luncheon at Engineering Societies Building.
2.00 p. m. Technical session.
Papers on the geology of several mining-districts and other subjects to be announced later will be presented and discussed at these sessions.

Annual Business Meeting.

The Annual Business Meeting of the Institute will be held at the Institute Headquarters, 29 West 39th Street, New York, N. Y., on Tuesday, Feb. 20, 1912, at 10 a. m. At this meeting members present, or by proxy, will elect a President, three Vice-Presidents, Secretary and three members of the Council, and three Directors of the Corporation; as required by the Constitution. A form of proxy, in the name of Dr. Leonard Waldo and Mr. Bradley Stoughton, which may be signed, witnessed, and returned to the office of the Institute, with or without alteration, has been sent to all members of the Institute. Members and Associates in arrears for dues of 1911, or residing outside of the United States, Canada, and Mexico, are not entitled to vote. The following names, comprising all the nominations received for offices of the Council, have been recommended by the Nomination Committee, which consisted of E. Gybbon Spilsbury, *Chairman*, James R. Finlay, Charles P. Perin, Arthur S. Dwight, and Louis D. Huntoon. Said nominations were approved by the Council at the regular meeting, Jan. 12, 1912.

For President of the Council.

James F. Kemp, ... New York, N. Y.
(Term expires February, 1913.)

For Vice-Presidents of the Council.

Benjamin B. Thayer, ... New York, N. Y.
Karl Eilers, ... New York, N. Y.
Waldemar Lindgren, ... Washington, D. C.
(Term expires February, 1914.)

For Secretary of the Council.

Joseph Struthers, ... New York, N. Y.
(Term expires February, 1913.)

For Members of the Council.

Joseph W. Richards, ... South Bethlehem, Pa.
John H. Janeway, Jr., ... New York, N. Y.
Sidney J. Jennings, ... Dobbs Ferry, N. Y.
(Term expires February, 1915.)

The following members of the Council are, under the Constitution, ineligible at this time for re-election to the positions they now hold, the terms of which will expire at the time of the Annual Business Meeting, Feb. 20, 1912: Benjamin B. Lawrence, Joseph W. Richards, and Albert Sauveur as Vice-Presidents of the Council; and Karl Eilers, Alex. C. Humphreys, and W. G. Miller as Councilors.

Aside from the election of officers and the presentation of the financial statement (to be subsequently published in the *Bulletin*

for the information of members), important issues bearing on the future development of the Institute will be presented for action, notably, the proposed Amendments to the Constitution, which, together with a special form of Proxy made out in the names of E. E. Olcott and George W. Maynard, have been published and sent, under date of Jan. 19, 1912, to all the members of the Institute.

The New York Section.

The next meeting of the New York Local Section of the Institute will be held in the Engineering Societies Building, 29 West 39th St., New York, N. Y., on Friday, Mar. 22, 1912, at 8.15 p. m.

At this meeting Prof. James F. Kemp will deliver an illustrated address on Iron-Mining in Swedish Lapland.

BENJAMIN B. LAWRENCE, *Chairman.*
BRADLEY STOUGHTON, *Secretary.*

165 Broadway, New York, N. Y.

Back Volumes of the Transactions.

The Board of Directors has authorized the following offers of sets of back volumes of the *Transactions*, at considerably reduced prices, to Members, Libraries, and Scientific Societies:

		Per Set.
I.	Five volumes, bound in half-morocco, from No. 36 (1906) to No. 40 (1910), ...	$20
II.	Ten volumes, bound in half-morocco, from No. 31 (1902) to No. 40 (1910), including Mexican Volume, . .	35
III.	Twenty volumes, bound in half-morocco, from No. 21 (1893) to No. 40 (1910), ...	50
IV.	Thirty volumes, bound in half-morocco, from No. 11 (1883) to No. 40 (1910), ...	60
V.	Thirty-nine volumes, bound in half-morocco, from No. 1 (1873) to No. 40 (1910), with the exception of No. 10 (1882), but including index for Volumes Nos. 1 to 35, and Nos. 36 to 40, ...	75
VI.	Nine volumes, bound in half-morocco, from No. 1 (1873) to No. 9 (1881), ...	25

Applications should be addressed to Joseph Struthers, Secretary, 29 West 39th Street, New York, N. Y.

Deferred Publication of the Year Book.

The *Year Book* of the Institute, which heretofore has been sent out with the January number of the *Bulletin*, and has covered the calendar year, Jan. 1 to Dec. 31, will not be issued this year until after the date of the Annual Meeting of the Institute, Feb. 20, 1912, thereby conforming to the official year of the Institute.

The Excursion to Japan.

BY ROSSITER W. RAYMOND, SECRETARY EMERITUS.

POSTSCRIPT.

On page 28 of the *Bulletin* for January, in my account of the late excursion to Japan, I mentioned the address delivered at the Imperial University of Tokyo by Dr. Henry S. Drinker, President of Lehigh University, and one of the original members of our Institute. Dr. Drinker left our party a day or two later, to proceed with his family to China, and homeward through Europe, so that I was unable to obtain the text of his address in time to publish it as a part of my story. I now print it as an important part of the record of that memorable excursion.

REMARKS OF DR. HENRY S. DRINKER, AT KYOTO, JAPAN.

Baron Kikuchi, President—and Gentlemen of the Faculty and Teaching Force, and of the Student Body, of the Imperial University of Kyoto:—It is a great pleasure to be able, after the inspection you have invited us to make of your buildings and equipment, and after meeting your large teaching force—to congratulate you, not as a mere matter of compliment, but intelligently and from our hearts, on the great work you are doing here for Japan in the promotion of higher education among your people.

We can see, from this inspection, that you are wisely concentrating the expenditure of your available resources on your faculty and equipment, rather than in the erection of pretentious buildings, which, though impressive outwardly to the eye, lack within the full complement of brainy men, by whose united work alone can your mission be properly accomplished. Your plant appears, however, to be adequate, and well adapted to the work to be done, and it is a surprise to us to see the equipment of your engineering departments so well represented and worked out.

On you, gentlemen of the faculty—leaders in your chosen work, rests a great responsibility. We envy you the privilege of its exercise in the educational training of your intelligent, earnest, forceful people, and we, who have come from our distant land across the seas, in meeting and studying your people, have learned from them lessons of love, of gentleness, of amiability, of courtesy, and of hospitality to the stranger and at home, that we have taken to heart, and that will abide with us as a gift and a keep-sake from the people of Nippon, more valued and more precious than much fine gold.

We have now been in your land for some days. We have seen your great seaport of Yokohama, and have been shown your capital city of Tokyo, and have traveled through your country to this ancient capital of the realm ; I personally have been greatly impressed by the fact that in our journeyings I have yet to see an instance of discourtesy or of rudeness, or to hear an unkind word, from one of your people to another ; and their cordial reception of our party has been universal. My good wife, who is with me, has noted, as I have done also, the loving care, everywhere apparent, shown to children in this wonderful land where the precept, "Love one another," is a practice, and not a theory only, of life, for while you tolerate and protect in your people the practice of all religions, you appear to follow and to have adopted the teachings and the practice of self-sacrifice and of altruism, with an exalted patriotism, as the leading principles of your life.

To your young men I heartily indorse the views expressed by Professor Richards, an experienced educator, that before they seek instruction in foreign lands, they avail of the excellent facilities now afforded by your own Universities in your own land, and that they go abroad only for special supplementary post-graduate studies for which special facilities may be open to them in other countries ; for today your progress in education has been so great, that you are no longer dependent on Europe and America.

To me personally, there is an intimate individual pleasure in this visit to the land of Nippon ; for of all our delegation of visiting engineers, I am, I think,

the only one who was, in any way, in touch with the events characterizing the passing of the old Japan into the new, now more than half a century ago. My father and mother were Americans living in Hongkong and in Macao from about 1840 to 1858, my father being a merchant in Hongkong, and I was born there in 1850. Commodore Perry was an intimate friend of our family, and a visitor at our home when engaged in the expedition in 1853 which resulted in the opening of your ports, and Townsend Harris, who, as the American Ambassador, negotiated with you in 1857 the original commercial treaty between our countries, was also our intimate friend.

While I was too young to receive impressions enabling me now to remember Commodore Perry, my memory of Mr. Harris is personal and loving; and the story of his and of Commodore Perry's friendship and association with us, and of the momentous events in which those great men led, is a precious tradition in our family. It is to me, therefore, a valued privilege now to visit Japan in the company of this delegation of leading scientific men of America. To rejoice with you in the triumph of your efforts for national progress, and to see in the character and conduct of your people the promise and potency of a further coming triumph greater than any you have achieved; greater than even your establishment of modern government in your nation in place of that which descended to you from the ages of the past—greater than the triumph of your marvelously successful industrial and educational progress and development—greater than the triumphs of war—of the Yalu—and of Nihon-kai—the triumph of Universal Peace, to which the enlightened nations of the world are so surely tending, and in which you, the nation leading Asia in enlightenment and progress, should stand hand in hand with America, strengthening by our joint action in this twentieth century the ties of the friendship the foundations of which were laid by Perry and Harris; a friendship which should be, and is, so real and abiding that it can never be weakened or broken by irresponsible agitators, or by hasty and unfounded misconceptions.

On p. 53 of my report, I dismissed with a line or two the graceful and interesting address delivered in the English language by Mr. Masayuki Otagawa, director and consulting engineer of the Furukawa Co., at the Nikko refining-works of that company, visited by our party on Thursday, Nov. 16, 1912 (erroneously printed, by the way, on p. 51 as Tuesday). Mr. Otagawa kindly wrote out his remarks afterwards, and forwarded to me a copy, which was received just too late to be included in my contribution to the January *Bulletin*. I publish them now, also taking this occasion to express to Mr. Otagawa the thanks of our party for his many personal courtesies, and our recognition of his eminent position among the engineers of Japan.

REMARKS OF MR. M. OTAGAWA, NIKKO COPPER-WORKS, NOV. 16, 1911.

Captain Hunt, Ladies and Gentlemen:—It is with much pleasure that I welcome you here on behalf of the Furukawa Mining Co., although I confess I am scarcely prepared to receive you in such a manner as I could wish, having myself been always on the road with you since your arrival in Japan. It is a great satisfaction that you have ventured to come up to this part of our country, when your departure for home is so near at hand. You are now in the heart of Japan, and you have already touched the hearts of the Japanese people! (Cheers.) At all events, I trust you may find some attraction to compensate for your journey hither. As you already know, Nikko is renowned for its beautiful temples, majestic crytomeria trees, and romantic scenery, so much so that the saying has come down to us from old times, "Don't say Kekko, until you have seen Nikko"; or, in other words, until you have seen Nikko you do not know the real meaning of the word 'Nekko' (magnificence). I feel that our copper-works are not worthy to be included in the category of Nikko's attractions, and that this eulogistic saying can hardly be applied to them; but I hope that you will find some truth in the time-honored saying, when you visit our beautiful temples to-morrow.

With reference to our copper industry, it is a pleasure to say that in mining and metallurgy, we owe a vast debt to you Americans, and particularly to your

American Institute of Mining Engineers. Our copper-works and copper-mines are modeled after the gigantic works in your country. As an illustration, Dr. Raymond was kind enough to mention in his eloquent address at the luncheon given by the Mayor of Tokyo, the Bessemer converters adopted at Ashio, which are perhaps in the order of their installation second only to those of Butte, with which the name of our friend Mr. Goodale, who is here at this table, has been associated for twenty-six years. Again, the series-process of electrolytic refining at the Nikko copper-works presents one of the only three examples of that method at present existing in the world; the other two being at the Nichols copper works, Laurel Hill, New York, and at the Baltimore copper-works, Maryland. Another interesting fact in this connection is, that the Nichols and the Baltimore copper-works produce one-third of the total output of the world's electrolytic copper, while the Nikko copper-works are credited with one-third of the electrolytic-copper production of Japan. (Cheers.) In the copper-production of the world, Japan ranks third, after the United States and Mexico; and it is most gratifying to us to have here as our guests, the representatives of the two greatest copper-producing countries in the world. We have followed the American way; it is indeed a pleasure to say that we are called the "Yankees of the East"; and I assure you we are proud of the name. (Cheers.)

The success of our copper-works, however, has not been attained by mere imitation, but has been the result of individual achievement. It is built on men. Besides trying to adopt things suitable for our purpose from America and Europe, we make it our chief aim and purpose to originate, or at any rate to adopt and improve methods, so as to meet our own conditions. We have always had at the helm competent men, who have received a systematic education and training. Dr. K. Yamaguchi, our former general manager, is an American product, being a graduate of John Hopkins University in Baltimore. He built the copper-works. Mr. K. Okumura, our present general manager, expects soon to double the output of the plant by the completion of a multiple process. (Cheers.)

I fear that the ladies present may not find these dry facts and figures very entertaining, therefore I should like to refer to another side of the subject, which may be a little more interesting to them. Copper-mining in Japan is an ancient industry, and the metallurgy of copper has been remarkably progressive in Japan since the old days. As early as 706 A.D., copper coins were minted in Japan, and our people have been acquainted, from time almost immemorial, with a smelting process called "Mabuki," which presents an interesting analogy with the Bessemer process.

During my stay in New York in 1906, I was asked to write an article on Japanese copper in *Mineral Industry*. I think I started it with "Boshana-Butsu," that huge image of Buddha which we saw last week at Nara. This gigantic bronze statue was erected between 743 and 752 A.D. The finish and workmanship may serve as an illustration of the advanced state of our copper industry over twelve centuries ago. Moreover, Japan seems to have given a considerable amount of attention to the mining industry, even in the early days of her history. In the time of Marco Polo, Japan was known in Europe as "The Island of Gold and Silver," and that famous voyager informed the West that there was a palace in Japan, roofed with golden tiles, and having ceilings made of the precious metals, and spangled with gold and silver ornaments. So valuable, indeed, was the treasure of this palace supposed to be, that it was even an attraction to Christopher Columbus, who aimed to reach Zipangu (Japan) in his voyage of discovery. While this report was greatly exaggerated, you will see to-morrow the Toshogu Temples, in the decoration of which silver and gold are lavishly employed. The copper tiles with which the temples, as well as the castle in Tokyo, are roofed, all come from the Ashio mines. Japan's copper-industry has always been in a prosperous condition; and more than 300 years ago Japanese copper was exported to Europe through the medium of the Dutch.

I think I have said about enough on this subject—perhaps too much. At any rate, I must take this opportunity to express regrets for my shortcomings in the capacity of a host. But I hope you will remember that I have always been with you on your pilgrimage; and, not being such a versatile actor as Baiko, whom we saw last night at the Empire Theater (Teikokugekijo), I find it very hard to make the quick change from a pilgrim to a responsible host! I should like to be the "Gold-haired Fox," and able to effect such a brilliant change as he did in the play; but, as it is, I have played only the part of a Copper Haired Fox! (Cheers.) I thank you for your kind attention.

John Fritz.

The autobiography of John Fritz, published by Wiley & Sons, presents as a frontispiece an excellent portrait of its venerable and beloved author. But the book itself, in its quaint simplicity, transparent sincerity, self-respecting modesty, and hearty human sympathy, is a still better picture of the man. It tells a story of patient endeavor as well as inborn genius, constituting an important chapter in the history of industrial progress through the application of science to engineering. The achievements of John Fritz as a mechanical engineer made the world his debtor; but the world owes him also a great debt for the example of his life.

This handsome volume contains, besides his picturesque and impressive story, told in his own words, contributions from several of his friends, and reports of public testimonials offered to him. It is a delightful and inspiring book, and will be treasured, after it has been enjoyed, by innumerable readers.—R. W. R.

Special Notice.

The *Bulletin* is now entered at the Post Office at Second-Class Postage rate of one cent per pound, and in order to preserve this privilege it will be necessary that the dues of members be paid within four months of Jan. 1, 1912. If the dues are not paid within the period mentioned, a member's name must be removed from the regular subscription-list and the *Bulletin* mailed at the transient second-class postage rate of one cent for each four ounces or fraction thereof, prepaid by stamps affixed. It is therefore earnestly requested that dues be paid promptly—otherwise the Institute will be put to additional expense of postage and to added labor in removing and replacing names from the regular list, and maintaining an additional separate mailing-list.

Library Research-Work.

The attention of members of the Institute is again directed to the research-work done by the librarian and his assistants, which should attract special attention from those members who have no access to the literature of subjects in which they may be interested. A list of recent searches follows:

Combustion of coal-dust; fusibility of ash; pyritic smelting; burning small sizes of coal; chromite-ore in Cuba; shaft-sinking; oil-pipe lines; cost of producing open-hearth steel; smoke-abatement; tunneling-machines; alloys of aluminum; mining asbestos; bog ore; boron manufacture; filter-presses (cyanide process); iron-ores from Yorkshire; mineral resources of Cyprus; electrolytic refining of copper; copper-deposits of Maryland; iron- and copper-deposits in Cuba; liquid and gaseous fuels; graphite in Ceylon; gold-dredges and dredging; graphite manufacture; Lowe gas-pro-

ducer; occurrence of magnesite; molybdenum; acid mine-water; gold-fields in Nevada; sulphur in Santo Domingo; timbering and lining of circular shafts; mines in Venezuela.

During the year 1911 there were 143 searches made for members and non-members of the Founder Societies, and copies of the references have been preserved for the use of others. This work has been largely based on requests sent in by mail, from Japan, South Africa, Mexico, Canada, and England, as well as from different parts of the United States. The Librarian is confident that if it were more widely known that the library is equipped to undertake researches, the demand would increase beyond the ability of the present force to handle it. The library receives more than 700 technical periodicals which are available through the indexes for this special purpose.

Local Sections.

The following regulations for the establishment of Local Sections of the Institute, issued in circular form and distributed to the membership May 26, 1911, are here republished for more convenient reference.

Regulations for the Formation and Conduct of Local Sections.

(Adopted May 19, 1911.)

1. A Local Section of the Institute may be authorized by the Council at the written request of *ten* members residing within an appropriate distance of a central point.
2. Only one Section shall be authorized in one locality or district.
3. The Council shall define the territory of a Section.
4. A Section must consist of twenty-five or more members; when its membership falls below twenty-five in number the Council may annul the Section.
5. Only members of the Institute shall be members of its Local Sections.
6. All members of the Institute, of all grades, residing within the territory of a Section shall *ipso facto* constitute the membership of such Section.
7. The officers of a Section shall be elected after the formation of the Section has been duly authorized, at a meeting of the members of the Institute within the territory of said Section, called by the sponsors of the Section, notice of said meeting and its object being given to said members at least thirty days in advance. Officers shall be elected for a term not longer than one year.
8. The officers of a Local Section shall be a Chairman, Vice-Chairman, Secretary, Treasurer (or Secretary-Treasurer), and such others as the Section may desire.
9. Whenever the Institute is financially able to do so, it shall be the policy of its Board of Directors to contribute from its funds for the legitimate running expenses of each Local Section an amount not exceeding, in each year, 25 per cent. of the dues received from the members of said Section in said year. Requests for such appropriations shall be signed by the Chairman, Secretary and Treasurer of the Section.

10. If the expenses of a Section exceed the appropriation made it by the Institute, the difference must be made up by voluntary contributions, but not by assessment upon the members of said Section. The Institute shall not be responsible for the debts of its Sections.

11. The Institute reserves the right to cancel a Section, or re-adjust its territory.

12. Papers presented at Local Sections, and discussions thereon if reported, are the property of the Institute. They shall be submitted to the Publication Committee and published in the *Bulletin* or *Transactions*, or both, if approved. Such papers shall not be published elsewhere without permission of the Council. The reading of a paper before a Local Section shall not carry with it the right of publication in the *Bulletin* or *Transactions* of the Institute.

13. Neither the author of a paper presented to a Local Section nor the Local Section shall have the right to reprint a paper or publish it in advance of the meeting without obtaining the permission of the Publication Committee of the Institute, which shall determine the details of such permission. Nothing herein shall forbid the abstracting of a paper by the press *after* its presentation before the Local Section.

14. The Institute shall print advance copies of papers offered to Local Sections, in order to facilitate discussion thereon, provided that such papers are approved for such advance publication by the Chairman or Secretary of the Local Section and by the Publication Committee of the Institute.

15. Papers read before a Local Section may also be offered for reading or discussion at general meetings of the Institute, and shall be given equal standing with the other papers on the program of said meeting, when approved by the Publication Committee.

16. Each Local Section shall transmit promptly to the Secretary of the Institute full announcements of its proposed meetings and an abstract of its proceedings, including the names of authors and titles of all papers read before it, for the purpose of preparing a report thereon to be published in the *Bulletin* of the Institute, and for the purpose of enabling the Council of the Institute to comply with articles 17 and 19 of these regulations.

17. The By-Laws and regulations of Local Sections shall be subject to the approval of the Council.

18. The Council reserves the right to amend, annul, or add to these regulations.

19. No action shall be taken by a Section which shall contravene the Constitution of this Institute.

CHARLES KIRCHHOFF, *President;*
JOSEPH STRUTHERS, *Secretary.*

The Emmons Research Fellowship of Economic Geology.

The Committee named below has been formed by friends of Samuel Franklin Emmons, late of the United States Geological Survey, to consider the best method of perpetuating his name. It has been decided that the memorial to him shall take the shape of

a Research Fellowship, to be known as the Samuel Franklin Emmons Research Fellowship of Economic Geology, which is to be administered by Prof. James F. Kemp, of Columbia University, New York. Subscriptions are invited by his friends to this fund, which the Committee has fixed at $25,000.

Members of the Institute who desire to contribute to this fund will please communicate with the Treasurer, Benjamin B. Lawrence, 60 Wall Street, New York.

The Committee consists of the following:

GEORGE OTIS SMITH, Director, U. S. Geological Survey, Washington, D. C.
H. L. SMYTH, Harvard University, Cambridge, Mass.
JAMES DOUGLAS, 99 John Street, New York, N. Y.
J. A. HOLMES, Director, Bureau of Mines, Washington, D. C.
JAMES F. KEMP, Columbia University, New York, N. Y.
F. W. BRADLEY, San Francisco, Cal.
J. PARKE CHANNING, 42 Broadway, New York, N. Y.
SEELEY W. MUDD, 1001 Central Building, Los Angeles, Cal.
D. W. BRUNTON, Denver, Colo.
H. FOSTER BAIN, 420 Market Street, San Francisco, Cal.
T. A. RICKARD, London, England.
B. B. LAWRENCE, 60 Wall Street, New York, N. Y.

Regulations for the Committee on Publication.

(*Adopted June* 16, 1911.)

1. The formation of a Publication Committee, consisting of the Secretary-Editor of the Institute, *Chairman*, and of at least twelve specialists, members of the Institute, who are willing to assist in passing on all papers offered for publication.

2. This committee shall perform its functions as follows:

(*a*) On the receipt of a paper by the Secretary, he shall send it to the member of this committee who, in his judgment, is most competent to pass upon it, accompanying the paper with his own opinion of its suitableness for publication, the history of the paper, and any other pertinent information.

(*b*) If the member of the committee and the Chairman agree upon the suitability or unsuitability of the paper, it shall be considered accepted for publication or rejected, as the case may be.

(*c*) If these two do not agree, the paper shall be submitted to a third, and the opinion of two of these three shall decide the matter.

(*d*) If a paper has been refused publication, the author may have the right of appeal, in which case the persons previously passing on the paper, together with others of the committee (appointed by the President) making five altogether, shall decide the question.

(*e*) If a paper has been accepted for publication, it shall be considered eligible to be placed on the program of a meeting.

3. The placing of a paper upon the program of a meeting does not give it the right to be published in the *Bulletin* or *Transactions* of the Institute; its suitability for publication must in every case be passed upon by the Publication Committee, as provided for in Section 2.

4. In case the Secretary is unable to secure a decision as to the suitability or unsuitability of a paper for publication, as directed in Section 2, before the time of announcing the program of a meeting, he may at his own discretion place the paper upon the program of the meeting, or refuse it a place thereon.

Affiliated Student Societies.

Any society of undergraduates at a technical school, comprising students in any branch of engineering, metallurgy, chemistry, geology, etc., may be recognized by the Council in its discretion as an Affiliated Student Society. A circular giving details of the plan of affiliation may be obtained on application to the office of the Secretary of the Institute.

The following societies have been placed by authority of the Council on the above list:

AFFILIATED STUDENT SOCIETIES.

The Mining Society of the Sheffield Scientific School, Yale University, New Haven, Conn. *President*, Karl C. Stadtmiller; *Secretary*, S. B. Gordy.

The University of Illinois Student Branch of the American Institute of Mining Engineers, Champaign, Ill. *President*, A. L. Voight; *Secretary*, M. L. Nebel.

The Engineering Society of the University of Nevada, Reno, Nev. *President*, Walter Harris; *Secretary*, E. R. Bennett.

The University of Wisconsin Mining Club, Madison, Wis. *President*, H. E. Schmidt; *Secretary*, W. V. Bickelhaupt.

The Mining and Geological Society of Lehigh University, South Bethlehem, Pa. *President*, William E. Fairhurst; *Secretary*, Carl W. Mitman.

The School of Mines Society of the University of Minnesota, Minneapolis, Minn. *President*, Emory P. Baker.

The Mining Engineering Society of the Massachusetts Institute of Technology. *President*, L. B. Duke; *Secretary*, Lionel H. Lehmaier.

The Student Auxiliary Society of the American Institute of Mining Engineers of the University of Kansas, Lawrence, Kan. *President*, A. H. Mangelsdorf; *Secretary*, C. J. Hainbach.

The Associated Miners of the University of Idaho, Moscow, Idaho. *President*, James W. Gwinn; *Secretary*, J. Wallace Strohecker.

The State College of Washington Mining and Geological Society, Pullman, Wash. *President*, R. V. Ageton; *Secretary*, W. M. McCarty.

The Tejas Technical Society, School of Mines, University of Texas. *President*, G. C. Cartwright; *Secretary*, David S. Alley.

The Ohio State University Student Branch of the American Institute of Mining Engineers, Columbus, Ohio. *President*, Hugh B. Lee; *Secretary*, E. P. Elliott.

The Stanford Geology and Mining Society, Stanford University, Cal. *President*, B. E. Parsons; *Secretary*, E. D. Nolan.

The Senior Mining Society of Columbia University, New York, N. Y. *President*, Roger L. Strobel; *Secretary*, Clark G. Mitchell.

Mining Association of the University of California, Berkeley, Cal. *President*, W. E. De Berry; *Secretary*, J. F. Dodge.

Tufts College Chemical Society, Tufts College, Mass. *President*, P. G. Savage; *Secretary*, W. S. Frost.

University of Washington Mining Society, Seattle, Wash. *President*, Horace H. Crary; *Secretary*, Clinton R. Lewis.

Student Branch of the American Institute of Mining Engineers, Iowa State College, Ames, Iowa. *President*, M. B. Hadley; *Secretary*, R. L. Hurst.

Missouri Mining Association of the Missouri School of Mines, Rolla, Mo. *President*, D. L. Forrester; *Secretary*, J. S. Irwin.

The Pick and Shovel Club of the Case School of Applied Science, Cleveland, Ohio. *President*, L. B. Riddle; *Secretary*, S. C. Stillwagon.

Colorado School of Mines Scientific Society, Golden, Colo. *President*, Alan Kissock; *Secretary*, George Wilfley.

How to Use the "Transactions" of the Institute.

Buy a copy of the Complete Analytical and Alphabetical Index of Volumes I. to XXXV., inclusive; also the new Index of Volumes XXXVI. to XL.

Whether you do or do not own a full set of the *Transactions*, these Indexes will make all of the material contained in the forty volumes available at once without detailed research into each volume separately. Moreover, an easy search will show what particular papers you need to know more about, and perhaps to study. Thus, any person possessing these Indexes can ascertain at once what has been published in the *Transactions* on a given question, and can learn, by writing to the Secretary, what is its nature, whether it is still to be had in pamphlet form, where it can be consulted in a public library, at what cost it can be copied by hand, etc., etc.

In short, to those who own complete sets of the *Transactions*, these Indexes will be a great convenience; but to those who do not, they will be a professional necessity.

The Index Volumes I. to XXXV. is an octavo of 706 pages, containing more than 60,000 entries, duly classified with sub-headings, and including abundant cross-references. The limited edition is becoming exhausted. The new Index, Volumes XXXVI. to XL., supplementing the Index Volumes I. to XXXV., brings the classified references up to the date of Volume XL., June, 1910. Prices: Index Volumes I. to XXXV., bound in cloth, $5; bound in half-morocco, to match the *Transactions*, $6. Index Volumes XXXVI. to XL., bound in cloth, $1.50; bound in half-morocco, $2.50. The delivery charges will be paid by the Institute on receipt of the above price.

Hydrographic Chart.

Owing to the great value to hydrographers of the chart contained in the paper, A Graphic Solution of Kutter's Formula, by L. I. Hewes and Joseph W. Roe (*Bulletin No.* 29, May, 1909, p. 454), a special edition for office or field use has been printed on durable cloth. Copies of this separate chart may be obtained, at a cost of 50 cents each, on application to the office of the Secretary of the Institute.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
AMERICAN INSTITUTE OF MINING ENGINEERS.
UNITED ENGINEERING SOCIETY.

WILLIAM P. CUTTER, Librarian.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

The Library contains about 42,000 volumes, including sets of technical periodicals and the publications of scientific and technical societies.

The members of the Institute, with few exceptions, are by the very nature of their profession forced to spend a large portion of their time in localities isolated from sources of information. To such members the Library can render valuable service through correspondence, and letters requesting information will receive special attention. The Library is prepared to furnish references and copies of articles on mining and metallurgical subjects; to determine, if possible, the existence of mining-maps, and to furnish general information as to the geology and mineral resources of all countries as far as these resources are known and published.

It is hoped that the members of the Institute will avail themselves freely of this special service. The Library will welcome inquiries on engineering subjects, and furnish information as far as such information is to be obtained.

All communications should be made as definite as possible so that the information received may be what is desired and not include collateral matter which may not be of interest. In this way the time spent in searching for such collateral matter will be saved, and as a result the information will be sent more promptly and in more usable shape.

The members of the Institute can be of service to the Library by forwarding copies of mining-reports, maps privately issued, and similar material, which will be classified, indexed, and made available to other members.

Suggestions for additions to the Library, either by purchase or personal solicitation as gifts, will be welcomed. It is hoped that members while in the city will use the Library freely, and assurance is given that most careful service will be rendered to them.

Library Accessions.

Jan. 1 to Jan. 31, 1912.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

ALUNITE. A newly discovered deposit near Marysvale, Utah. (Bulletin No. 511, U. S. Geological Survey.) Washington, 1912. (Exchange.)

AMERICAN ELECTROCHEMICAL SOCIETY. Transactions. Vol. 20, 1911. South Bethlehem, 1911. (Exchange.)

AMERICAN GEOGRAPHICAL SOCIETY. Journal. Vol. 3. Albany, 1873. (Exchange.)

APPLIED GEOLOGY. By A. H. Brooks. (Reprinted from *Journal of the Washington Academy of Science*, vol. II., No. 2, Jan. 19, 1912.) N. p., n. d. (Gift of Author.)

APPROXIMATE COST OF A CANAL BETWEEN BAY HEAD AND THE SHREWSBURY RIVER. Report to the 135th Legislature. (Bulletin No. 2, New Jersey Geological Survey.) Trenton, 1911. (Exchange.)

ASSAYING AND METALLURGICAL ANALYSIS FOR THE USE OF STUDENTS, CHEMISTS, AND ASSAYERS. Ed. 2. By E. L. Rhead and A. H. Sexton. London–New York. Longmans, Green & Co., 1911. (Purchase.)

ATLAS GÉNÉRAL DES HOUILLÈRES. By E. Gruner et G. Bousquet. Two vols. Paris, 1911. (Purchase.)

BERICHT DER SENCKENBERGISCHEN NATURFORSCHENDEN GESELLSCHAFT IN FRANKFURT AM MAIN. 42, PTS. 1–4, 1911. Frankfurt am Main, 1911. (Gift of James Douglas.)

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. Report, 1902–1909. London, 1903–1910. (Purchase.)

BURKETOWN MINERAL FIELD (silver-lead and zinc mines). (Publication No. 232, Queensland Geological Survey.) Brisbane, 1911. (Exchange.)

CANADA. MINES DEPARTMENT. Report on the Gypsum Deposits of the Maritime Provinces. Ottawa, 1911. (Exchange.)

CASE SCHOOL OF APPLIED SCIENCE. Catalogue, 1911–1912. Cleveland, 1911. (Gift of Case School of Applied Science.)

CHEMIKER-KALENDER, 1912. By Rudolf Biedermann. Two vols. Berlin, 1912. (Purchase.)

CIENCIAS PEDAGÓGICAS Y FILOSOFIA. Tomo II. (Congreso Cientifico (1° Pan Americano) volume XIII.) Santiago de Chile, 1911. (Gift of Congreso Cientifico.)

CONTRIBUTIONS TO ECONOMIC GEOLOGY (Short Papers and Preliminary Reports), 1910, Part I. (Bulletin No. 470, U. S. Geological Survey.) Washington, 1911. (Exchange.)

CORNELL UNIVERSITY LIBRARY. Librarian's Report, 1910–1911. Ithaca, 1911. (Exchange.)

DESCRIPTION OF THE FOSSIL FISH REMAINS OF THE CRETACEOUS, EOCENE AND MIOCENE FORMATIONS OF NEW JERSEY. (Bulletin No. 4, New Jersey Geological Survey.) Trenton, 1911. (Exchange.)

DREDGING OF GOLD PLACERS. By J. E. Hodgson. London, 1911. (Purchase.)

EINLEITUNG IN DIE CHEMISCHE KRYSTALLOGRAPHIE. By P. Groth. Leipzig, 1904. (Purchase.)

L'ELECTROCHIMIE. Vols. 3–6. Paris, 1897–1900. (Purchase.)

ENGINEERING STANDARDS COMMITTEE. British Standard Definitions of Yield Point and Elastic Limit. (No. 56.) Westminster, 1911.

——— British Standard Specifications for Material used in the Construction of Railway Rolling Stock. (No. 24, revised.) London, 1911.

——— Report on British Standard Heads for Small Screws. (No. 57.) London, 1911. (Gift of Engineering Standards Committee.)

FERRO-MAGNÉTISME. By R. Jouaust. Paris, 1911. (Purchase.)

FLORA OF THE RARITAN FORMATION. (Bulletin No. 3, New Jersey Geological Survey.) Trenton, 1911. (Exchange.)

GENERAL SUMMARY OF THE MINERAL PRODUCTION OF CANADA DURING 1910. (Canada Mines Department. No. 117.) Ottawa, 1911. (Exchange.)

GEOLOGICAL LITERATURE ADDED TO THE GEOLOGICAL SOCIETY'S LIBRARY DURING 1910. London, 1911. (Exchange.)

I GIACIMENTI PETROLEIFERI DELL 'EMILIA. (Memorie descriptive della Carta Geologica D'Italia. Vol. XIV.) Bologna, 1911. (Gift of Corpo Realle della Miniere.)

——— ——— Atlas.

GRAPHICAL SOLUTION OF FAULT PROBLEMS. By C. F. Tolman, Jr. San Francisco, 1911. (Gift of *Mining and Scientific Press.*)

[NOTE.—This compact little treatise deals in an elementary way with a subject which has received little attention in American technical literature. The author is a professor in the School of Mines of the University of Arizona, and the book, composed of material selected from his course in structural geology, is another proof of the usefulness and *raison d'être* of such institutions. (A similar proof was given in the paper of Prof. George J. Young, of the Mackay School of Mines at Reno, Nev., on Slime-Filtration, read at the San Francisco meeting of October last, and published in the November *Bulletin.*) We are receiving from these sources, located as they are in immediate contact with pressing problems of practice, most valuable contributions of accurate observations, careful experiments, and acute scientific discussions, concerning questions of professional importance. It has been said sometimes that the numerous American mining schools are turning out mining engineers in excess of the demand for them ; but, however that may be, it is certain that they are supplying professional knowledge for which the demand cannot be exceeded.

Professor Tolman does me the honor to recall my paper (*Trans.*, x, 456), read at the Washington meeting of February, 1882, on "Hoefer's Method of Determining Faults in Mineral Veins," as a discussion not continued, until recently, in the English language. He cites only Mr. Reid's paper on "The Geology of Faults," presented in December, 1908, to the Geological Society of America, and published in the *Bulletin* of that Society in May, 1909, aside from his own publications on the subject.

In 1882, when my paper was presented, I hoped to follow it with other essays; but in 1883 I was appointed Secretary of the Institute, and in 1884, and 26 subsequent years I was elected to that office, so that for more than 27 years I was too heavily burdened with official work to realize the professional ambitions of my youth in the line of independent authorship. I am glad to see other men, better equipped for such undertakings, fulfilling my abandoned aspirations.

Professor Tolman's treatise is an excellent introduction to a complicated study. It discusses briefly the nomenclature of fault-movements ; methods of projection for graphical treatment; elementary problems in line and plane intersections; fault-movements of pure translation along vertical and inclined planes; and problems involving rotation as well as simple translation.—R. W. R.]

GREAT BRITAIN. Inspectors of Explosives. Annual Report, 28th–35th. London, 1904–1911. (Purchase.)

HANDBOOK OF THE MINERAL RESOURCES OF GEORGIA. Atlanta, 1911. (Exchange.)

HANDBUCH DER MINERALCHEMIE. By C. Doelter. Vol. 1, No. 4. Dresden, 1911. (Purchase.)

HARVARD UNIVERSITY. Catalogue, 1911–1912. Cambridge, 1911. (Exchange.)

HEMATITE ORES OF BRAZIL AND A COMPARISON WITH HEMATITE ORES OF LAKE SUPERIOR. By C. K. Leith and E. C. Harder. N. p., n. d. (Reprinted from *Economic Geology*, Oct.–Nov., 1911.) (Gift of Authors.)

ILLUSTRIERTE TECHNISCHE WÖRTERBÜCHER. Band XI. Eisenhüttenwesen. By A. Schlomann. München-Berlin, 1911. (Purchase.)

INSTITUTION OF MINING AND METALLURGY. Constitution and By-laws and List of Members, 1912, London, 1912. (Exchange.)

tion; the limitations of the single-unit and 5-stamp unit batteries; the history and practice of amalgamation in connection with stamp-mills; and the details of stamp-mill construction.—R. W. R.]

SURFACE WATER SUPPLY OF THE UNITED STATES, 1910. Part VI. Missouri River Basin. (Water Supply Paper No. 286.) Washington, 1911. (Exchange.)

—— Part VII. Lower Mississippi Basin. (Water Supply Paper No. 287, U. S. Geological Survey.) Washington, 1911. (Exchange.)

TYPES OF ORE DEPOSITS. Edited by H. F. Bain. San Francisco, 1911. (Gift of *Mining and Scientific Press.*)

[NOTE.—This book is a useful compilation of monographs by competent experts, describing ore-deposits of various types. It comprises not only articles contributed to the *Mining and Scientific Press*, but also papers presented to the Canadian Mining Institute, and contributions based on the *Transactions* of this Institute and the publications of the U. S. Geological Survey, the State Surveys, etc. Mr. H. Foster Bain, of the *Mining and Scientific Press*, who has edited the book, deserves credit for his intelligent selection and arrangement of its materials. It contains chapters on "The Clinton Type of Iron-Ore Deposits" (C. H. Smyth, Jr.); "The Lake Superior Type of Iron-Ore Deposits" (C. K. Leith); "Flats and Pitches of the Wisconsin Lead- and Zinc-District" (H. Foster Bain); "Lead and Zinc-Deposits of the Ozark Region" (E. R. Buckley); "Native Copper-Deposits" (Alfred C. Love); "The Cobalt District. Ontario" (S. F. Emmons); "The Geology of the Treadwell Mines" (Oscar H. Hershey); "The Saddle-Reef" (T. A. Rickard); Contact-Deposits" (J. F. Kemp); "The Conglomerates of the Witwatersrand" (I. H. Hatch); "Replacement Ore-Bodies, and the Criteria by means of which They may be Recognized" (J. D. Irving); "The Outcrop of Ore-Bodies" (William H. Emmons); and "Some Courses of Ore-Shoots" (R. A. F. Penrose, Jr.). Both the list of topics and the names of authors guarantee the interest and value of the compilation.—R. W. R.]

U. S. CENSUS BUREAU. Mortality Statistics, 1910. (Bulletin No. 109.) Washington, 1912. (Exchange.)

U. S. GEOLOGICAL SURVEY. Annual Report of the Director, 32d, 1911. Washington, 1911. (Exchange.)

VEREIN FÜR DIE BERGBAULICHEN INTERESSEN IM OBERBERGAMTSBEZIRK DORTMUND. Plates to accompany Band IV, pl. 37–44, 46–47, 49–56, 58; Band V, pl. 63, 66, 69–71, 75–76, 81–90; Band VI, pl. 91, 92, 94–97, 99–101, 103, 106–110; Band IX, pl. 1–18, 20–43, 45–51. (Gift of Maurice Deutsch.)

WASHINGTON GEOLOGICAL SURVEY. Bulletin No. 5. Olympia, 1911. (Exchange.)

YALE UNIVERSITY. General Catalogue, 1911–1912. New Haven, 1911. (Exchange.)

GIFT OF DR. JOSEPH STRUTHERS.

EARNING POWER OF RAILROADS, 1911. Compiled and edited by F. W. Mundy. New York, J. H. Oliphant & Co., 1911.

GENERAL MAP OF THE CANAL ZONE AND THE PANAMA CANAL. N. d.

ISTHMIAN CANAL COMMISSION. Profile showing estimated quantity of material to be excavated after June 30, 1909, to complete the Panama Canal. July 6, 1909.

JAPAN. DEPARTMENT OF FINANCE. Eighth and Ninth Financial and Economic Annual. Tokyo, 1908–1909.

—— Mineral Production at Principal and Other Mines, 1909. N. p., n. d.

MAP SHOWING CANAL ZONE, LOCATION AND AUXILIARY STRUCTURES OF THE ISTHMIAN CANAL. July, 1909.

STATEMENT RELATIVE TO THE PANAMA CANAL (typewritten.) N. d.

GIFT OF KIRBY THOMAS.

ASBESTOS. A Short Talk on Asbestos. Quebec, 1909.

ALGOMA EASTERN RAILWAY CO. Prospectus. London, 1911.

ARCHISE COPPER CO. Description. New York, 1910.

BURCKHARDT, CARLOS. Estudio Geologico de la Region de San Pedro del Gallo, Durango. Mexico, 1910.

CALIFORNIA CONSOLIDATED MINES CO. Description. N. p., n. d.

COPPEROSITY COPPER CO. Report on the Properties. Arizona, 1907.

EL CHANATE MINING & MILLING CO. Official Statement. Los Angeles, N. d.

FACTS ABOUT THE ELDORADO MINES, CLARK COUNTY, NEV. N. p., n. d.

FRENZEL, A. B. Report on the Tungsten Mountain Mines Co.'s Property. Denver, 1911.

HENRIKSEN, G. Geological Notes. Christiania, 1910.

MARY MINING CO. History and Prospects. N. p., n. d.

MITCHELL MINING CO. Description. New York, 1905.

MONTE RICO MINING & MILLING CO. Prospectus. Washington, Pa., n. d.

NEVADA-DOUGLAS COPPER CO. A Book of Facts. N. p., n. d.

NICKEL ALLOYS CO. Advance Detailed Report. N. p., 1911.

PAST, PRESENT AND FUTURE OF COPPER. An Address Delivered before the American Mining Congress, Oct. 25, 1911. By H. J. Stevens.

PRODUCTION, ESTIMATED EARNINGS AND DIVIDENDS OF THE IMPORTANT COPPER MINES OF THE UNITED STATES, MEXICO AND CANADA. April, 1911.

QUEBEC : Its Mineral Wealth and Opportunities.

QUEBEC MINES AND METAL CO., LTD. Prospectus. N. p., n. d.

ST. JULIEN COPPER MINES ON THE ISLAND OF NEWFOUNDLAND. Report No. 37. N. p., n. d.

TRADE CATALOGUES.

E. R. ALLEN FOUNDRY CO., Corning, N. Y. Elliott mechanical stoker. 7 pages.

CHICAGO PNEUMATIC TOOL CO., New York, N. Y.

Bulletin No. 34 A. Class "G" pneumatic steam-driven compressors. 16 pages.

Bulletin No. 34 C. Tandem gasoline-driven compressors. 16 pages.

Bulletin No. 34 E. "Railroad type," straight line, duplex steam-driven and belted compressors. 18 pages.

Bulletin No. 34 H. General instructions for installing and operating "Chicago Pneumatic" compressors. 16 pages.

INGERSOLL-RAND CO., New York, N. Y. "Imperial" valveless telescope-feed hammer-drill. 16 pages.

KENNICOTT CO., Chicago Heights, Ill. Water-storage purification and measurement for industrial purposes. 14 pages.

MERRITT & CO., Camden, N. J. Priestman ejector system, using compressed air expansively. 12 pages.

PENNSYLVANIA CRUSHER CO., Philadelphia, Pa. Crushers and coal-cleaners. 16 pages.

SEAGER ENGINE WORKS, Lansing, Mich. Gas, gasoline and kerosene engines. 48 pages.

STROMBERG-CARLSON TELEPHONE CO., Chicago, Ill. Bulletin No. 1003. Telephone supplies and telephone construction material for mines. 206 pages.

United Engineering Society Library.

AUTOBIOGRAPHY OF JOHN FRITZ. New York, 1912. (Gift of John Fritz.)

IOWA RAILROAD COMMISSIONERS. Annual Report, 33d, 1910. Des Moines, 1910. (Gift of American Electric Railway Association.)

GESCHÄFTS-BERICHT DER DEUTSCHEN BUCHDRUCKER BERUFS-GENOSSENSCHAFT ÜBER DAS RECHNUNGSJAHR 1910. Frankfurt am Main, n. d. (Gift.)

VIRGINIA STATE CORPORATION COMMISSION. Annual Report, 8th, 1910. Richmond, 1911.

——— Appendix to Annual Report, 8th, 1910. Richmond, 1911. (Gift of T. C. Martin.)

WISCONSIN RAILROAD COMMISSION. Opinions and Decisions. Volume IV. Madison, 1910. (Gift of American Electric Railway Association.)

TRADE CATALOGUES.

AMERICAN VANADIUM Co., Pittsburg, Pa. Nine photographs of vanadium-steel machine parts. 9 pages.

H. CHANNON Co., Chicago, Ill. Machinery and general supplies for railroads, manufacturing and power-plants. 952 pages.

DU PONT DE NEMOURS POWDER Co., Wilmington, Del.

Use of explosives on the farm. 118 pages.

Dynamiting boulders and stumps. 28 pages.

Tree planting with Du Pont dynamite. 24 pages.

FAY & EGAN Co., Cincinnati, O. Wood-working machinery. 384 pages.

FORBES Co., Philadelphia, Pa. Water sterilization by heat. 80 pages.

MUNNING-LOEB Co., Matawan, N. J. Belt-driven and motor-driven electroplating dynamos. 19 pages.

TINIUS OLSEN & Co., Philadelphia, Pa.

Part A.—Catalogue of testing-machinery and instruments. 66 pages.

Part B.—Spring-testing machinery. 16 pages.

Part C.—Cement-testing apparatus. 19 pages.

Part D.—Fiber-, paper-, glue-, rubber-testing machinery. 12 pages.

Part E.—Wire-, chain-, anchor-testing machinery. 20 pages.

Part F.—Oil-, grease-, bearing-metal testing machinery. 10 pages.

Part G.—Transverse-testing machinery. 8 pages.

Part H.—Special testing-machinery. 24 pages.

MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of January, 1912.

Members.

ARNOLD, RALPH, Cons. Geol. and Engr.......Union Oil Bldg., Los Angeles, Cal.
COTTRELL, FREDERICK G., Chief Physical Chem., U. S. Bureau of Mines, 506 U. S. Custom House, San Francisco, Cal.
JUI, PAO VUNG, Min. Engr.............Care U. S. Postal Agency, Shanghai, China.
KERVIN, GEORGE A.....................Asst. Supt., Mammoth Smelter, Kennett, Cal.
LAUCKS, IRVING F., Min. Engr........................95 Yesler Way, Seattle, Wash.
McGINNIS, RICHARD B., Min. Engr....................Mills Bldg., San Francisco, Cal.
PAINE, FRANCIS W., Instructor in Econ. Geol., Mich. College of Mines, Houghton, Mich.
PALMER, CHARLES H., JR., Min. Engr., Nevada Cons. Copper Co., East Ely, Nev.
PARSONS, ROSCOE R. S........Genl. Mgr., St. Joseph Lead Co., Bonne Terre, Mo.
THOMPSON, CHARLES H., Mine Mgr..........................Darbyville, Lee Co., Va.
TRENERRY, EDWARD J., Mine Officer..................Moonta Mines, So. Australia.
WILKINS, LLEWELLYN H., Cons. Engr., Finsbury Pavement House, London, E. C., England.

Associate.

LONSBERY, GEORGE A., Mine Mgr., 1144 Title Insurance Bldg., Los Angeles, Cal.

CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the month of January, 1912. This list, together with the foregoing list of new members and the lists printed in *Bulletin* Nos. 50 to 61, therefore, supplements the annual list of members corrected to Jan. 1, 1911, and brings it up to the date of Feb. 1, 1912.

ALDRICH, TRUMAN H., Postmaster....................................Birmingham, Ala.
ALMY, WILLIAM F...P. O. Box 123, Nashua, N. H.
ALEXANDER, CURTIS..................................Apartado 320, San Luis Potosi, Mexico.
APPLEGREN, J. O. W...323 Ralston St., Reno, Nev.
AUBURY, LEWIS E...Burlingame, Cal.
BARD, DARSIE C..........................Montana State School of Mines, Butte, Mont.
BATCHELLER, JAMES H...........Care Tomboy Gold Mines, Ltd., Smuggler, Colo.
BEALL, ALBERT S. E., Rix Compressed Air & Drill Co., 120 E. 3d St., Los Angeles, Cal.
BEARD, JAMES T., Sr. Asso. Editor, *Coal Age*.....505 Pearl St., New York, N. Y.
BELL, J. MACKINTOSH................621 Salisbury House, London, E. C., England.
BENTLEY, THOMAS H.......................................P. O. Box 156, Carlton, Ore.
BLACKMER, WILLIAM D...........................University Club, Los Angeles, Cal.
BLAKE, D. E..1029 Covana St., Denver, Colo.
BLOW, A. A...................White Investing Co., 55 Liberty St., New York, N. Y.
BLOW, JOHN J...............15 Campden Hill Court, Kensington, London, England.
BOLLES, J. H..265 W. 81st St., New York, N. Y.
BRADEN, WILLIAM, Cons. Min. Engr., Room 1805, 27 William St., New York, N. Y.
BRADLEY, PHILIP R............................1023 Crocker Bldg., San Francisco, Cal.

BRAYTON, COREY C., Asst. Genl. Mgr., Natomas Cons. of Calif., 701 Peoples Bank Bldg., Sacramento, Cal.
BROCKUNIER, SAMUEL H....Nevada City, Cal.
BROOKS, RAYMOND....Mission, Tex.
BROWN, ALFRED....Godfrey Terrace, Leabrook, So. Australia.
BROWNE, SPENCER C....402 Edwards St., Oakland, Cal.
BUSEY, ALFRED P., JR....Penn Mining Co., Campo Seco, Cal
BUSH, B. F., Prest., Missouri Pacific, and Denver & Rio Grande R. R. Cos., St. Louis, Mo.
CALDWELL, HALSTED W....Oxford, N. C.
CALLBREATH, JAMES F., JR., Secy., Am. Mining Congress, 725 Majestic Bldg., Denver, Colo.
CHADBOURNE, H. W....30 Pine St., New York, N. Y.
CHIBAS, LUIS F....Calvario baja 14, Santiago de Cuba, Cuba.
CLARK, FRED....109 Lick Bldg., San Francisco, Cal.
COX, HERBERT B....Calais, Me.
DART, ALBERT C....P. O. Box 542, Canon City, Colo.
DAVIS, WILLIAM J., JR., Genl. Electric Co., 720 Rialto Bldg., San Francisco, Cal.
DICKSON, A. A. C....Kodarma, E. I. R, India.
DOERR, ALBERT....1632 Fletcher Ave., So. Pasadena, Cal.
EDELSTEEN, KARL J., Min. and Civ. Engr., Sullivan Machinery Co., Mayer, Ariz.
ELLIS, RALPH W., Cons. Min. Engr., 195, San Martin, Buenos Aires, Argentine Rep., So. Am.
EMMENS, NEWTON W....606 Hastings St. W., Vancouver, B. C., Canada.
EU, SIANG HYE....Scotland House, Penang, Straits Settlements.
EVERED, NUTCOMBE J....Care J. D. Evered, Medicine Hat, Alta., Canada.
FARRAR, BENJAMIN L....352 Centre St., Bangor, Me.
FINLETTER, JOHN R....625 St. Francis Hotel, San Francisco, Cal.
FORBES, DONALD G....Union Club, Victoria, B. C., Canada.
FOUCAR, EDOUARD L....512-18 Folsom St., San Francisco, Cal.
FREYMUTH, WILLIAM A., Econ. Geol....Rewa State, Umaria, Central India.
GARREY, GEORGE H., Min. Geol., Am. Smelt. & Refin. Co., 165 Broadway, New York, N. Y.
GILMAN, CHARLES E....406 Syndicate Bldg., Oakland, Cal.
GIRAULT, EDMUNDO, Min. and Met. Engr., Apartado 79, Pachuca, Hid., Mexico.
GLEASON, FRANK A., Spl. Min. Engr., D. L. & W. R. R., C. M. D., 1911 Capouse Ave., Scranton, Pa.
GORMLY, SAMUEL J....3063 E. 6th St., Los Angeles, Cal.
GRABILL, CLARENCE A., Cia. Metalurgica Nacional, Matehuala, S. L. P., Mexico.
GRAHAM, STANLEY N....Care Geological Survey, Ottawa, Ont., Canada.
GRAVE, ERNEST, Director de la Cia. Minera de los Reyes, S. A., Los Reyes, Jal., Mexico.
GUESS, GEORGE A., Prof. Met....Univ. of Toronto, Toronto, Ont., Can.
HAMILTON, THOMAS M., Supt. Cia. Metalurgica Nacional, Charcas, S. L. P., Mexico.
HOLMES, FREDERICK C....P. O. Box 2, San Juan, Porto Rico.
HUNTOON, LOUIS D....52 Broadway, New York, N. Y.
HYBINETTE, VICTOR....Somerrogaden 15, Kristiania, Norway.
INGLIS, J. F....Eureka Windfall Mining Co., Eureka, Nev.
IRWIN, DAVID D....Care W. R. Cox, Metcalf, Ariz.
JONES, EVAN R....Fenix Coal Co., El Fenix, Coah., Mexico.
KELLER, ARTHUR H....Santa Rosa, Dep. Copan, Republic of Honduras, C. A.
KIDWELL, EDGAR, Cons. Engr....2011 Channing Way, Berkeley, Cal.
KIRKEGAARD, PETER....Quebec Bank Bldg., 2 Toronto St, Toronto, Ont., Can.
LAIRD, WILBUR G....Improved Equipment Co., 60 Wall St., New York, N. Y.
LEGGAT, ALEXANDER....Idaho Tungsten Co., Patterson, Idaho.
LEMPRIERE, OSCAR T....506 Little Collins St., Melbourne, Vic., Australia.
LEWIS, J. VOLNEY....Prof. of Geol., Rutgers College, New Brunswick, N. J.
LIHME, CHRISTIAN B....130 Astor St., Chicago, Ill.
LODGE, RICHARD W....P. O. Box 84, Redlands, Cal.
LOOMIS, WILLIS H....Orbisenia, Pa.
MCCHRYSTAL, JOHN H....Box F, Eureka, Utah.
MCCRERY, CHARLES....Riverside Inn, Saranac Lake, N. Y.
MACDONALD, JESSE J., Met. Engr., Magna Plant, Utah Copper Co., Garfield, Utah.

MARSHALL, STEWART McC.............................134 Tioga St., Johnstown, Pa.
MARTIN, NICHOLAS J...............Supt., Beaver Gold Dredging Co., Loomis, Cal.
MEEKS, REGINALD..............Vinton Colliery Co., 1 Broadway, New York, N. Y.
METZGER, WILLIAM G.........................Poteau Valley R. R. Co., Poteau, Okla.
MIRANDA, JAGUANHARO DE, Rua Larangeiras 304, Rio de Janeiro, Brazil, So. Amer.
MITCHELL-ROBERTS, J. F......8 Eliot Hill, Blackheath, London, S. E., England.
MOORE, GEORGE...330 W. 102d St., New York, N. Y.
MUNRO, DUNCAN M.................Mineral de la Bonanza, Zimapan, Hid., Mexico.
NIGHMAN, CLARE E...Instructed to hold all mail.
NOLD, FREDERICK B.........Republic Iron & Steel Co., Republic, Fayette Co., Pa.
PEIRCE, WILLIAM H., Vice-Prest., Baltimore Copper Smelting & Rolling Co., P. O. Sta. J., Baltimore, Md.
PHILLIPS, WALTER I..Mogollon, N. M.
PLOCK, ALBERT F...3506 5th Ave., Pittsburg, Pa.
POTTER, WILLIAM C., Continental Rubber Co. of N. Y., 17 Battery Pl., New York. N. Y.
PRICHARD, WILLIAM A........................Care Bank of Palo Alto, Palo Alto, Cal.
PROSSER, HERMAN A....................................165 Broadway, New York, N. Y.
QUARRIE, BERTRAM D., Genl. Supt., Newburgh Steel Wks. & Furnaces, Cleveland, Ohio.
RICHARDS, GEORGE M., Care Union of London & Smith's Bank, Ltd., London, England.
RIGHTOR, FRED E...............Texas Bitulithic Co., P. O. Box 314, Austin, Texas.
ROBBINS, CHARLES P..................................1043 Third St., Santa Monica, Cal.
RODGERS, JOSEPH H..........................707 American Bank Bldg., Seattle, Wash.
RONE, LLOYD A., Cia. Minera "San Mateo," S. A., Apartado 36, Valardena, Dur, Mexico.
RUGGLES, GUY H...404 N. Ball St., Webb City, Mo.
SAMWELL, NICHOLAS....................................P. O. Box 385, Rangoon, Burma.
SANDERS, JOHN...3306 Alameda Ave., El Paso, Tex.
SCHRADER, ERICH J....................................694 Marshall Ave., St. Paul, Minn.
SAWYER, ARTHUR H...................................304 Florence St., Houghton, Mich.
SHAW, JAMES B...............................41 Wicksteed St., Danganin, New Zealand.
SIEBERT, FREDERIC J., Min. Engr...Reno, Nev.
SMALLEY, WILLIAM W.......................................P. O. Box 797, Coalinga, Cal.
SMITH, WILLIAM ALLEN......................St. Joseph Lead Co., Herculaneum, Mo.
SNOW, FREDERICK W..17 Franklin St., Lynn, Mass.
SNYDER, BAIRD, JR., Cons. Engr...Pottsville, Pa.
STARKEY, TOM R...................Care King & Co., Belize, British Honduras, C. A.
STAVER, WILLIAM H., Min. Engr., Supt., Liberty Bell G. M. Co., Telluride, Colo.
STOCKDALE, ARTHUR H., Mgr. Cia. Minera y Beneficiadora de "Maravillas y San Francisco." Apartado 21, Pachuca, Hid., Mexico.
TAYLOR, WILLIAM W., Vice-Prest. and Genl. Mgr., Oriskany Ore & Iron Corpn., Lynchburg, Va.
THOMPSON, MALCOLM M....................................P. O. Box 26, Ridgefield, N. J.
TOLL, RENSSELAER H......................................410 Boston Bldg., Denver, Colo.
TRYON, CHARLES T..Noria, Son., Mexico.
TYLER, VICTOR M...............................P. O. Box 1333, New Haven, Conn.
TYSSOWSKI, JOHN...............................Box 37, R. F. D. 4, Washington, D. C.
UREN, WILLIAM J......................................124 College Ave., Houghton, Mich.
WAITE, HENRY M., Chief Engr., Dept. of Public Service, City Hall, Cincinnati, Ohio.
WECK, CHARLES A......................................Bluestone M. & S. Co., Mason, Nev.
WEIR, CHARLES G...21 E. 82d St, New York, N. Y.
WEST, HAARLEM E..................Care Barclay & Co., Hayle, Cornwall, England.
WICKES, GEORGE T......................................The Montana Club, Helena, Mont.
WICKWARE, FRANCIS G...................................28 W. 63d St., New York, N. Y.
WOLF, ALBERT G...Liberty Bell Club, Telluride, Colo.
WOLF, ALBERT H......................Rooms 721-22, 206 La Salle St., Chicago, Ill.
WOLF, HARRY J., Min. Engr...............640 Gas & Electric Bldg., Denver, Colo.
WOLF, MARTIN Y...1748 Beach St., San Diego, Cal.
WOOD, GEORGE R., Elec. Dept., Berwind-White Coal Mining Co., Arcade Bldg., Philadelphia, Pa.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address of Record, from which Mail has been Returned.
Cook, Edward H.,	Minas Birimoa, S. A, Birimoa, via Canelas, Dur., Mexico.
Danforth, A. H.,	Cotopaxi, Colo.
Edwards, Robert L.,	P. O. Box 1673, Salt Lake City, Utah.
Fitzgerald, Thomas F. M.,	211 Sharon Bldg., Salt Lake City, Utah.
Fleming, John B.,	Nevada Hills Mining Co., Fairview, Nev.
Furness, James W.,	Coffee, Trinity Co., Cal.
Geiger, Arthur W.,	Cortez, via Beowawe, Nev.
Goodloe, Meade,	So. Ariz. Smelting Co., Sasco, Ariz.
Hagemann, Wilhelm,	Metates, via Tepehuanes, Dur., Mexico.
Hawkins, Tancred,	Red Bandana Gold Mine, Elizabethtown, N. M.
Johnson, Dion L.,	325 Water St., Pittsburg, Pa.
Kimball, Edwin B.,	Alaska-Commercial Bldg., San Francisco, Cal.
Lampshire, John O.,	Vulture Mine, Wickenburg, Ariz.
Leavell, John H.,	Buffalo Mine, Cobalt, Ont., Canada.
Le Noir, Frank H.,	Box 16, Mt. Bullion, Cal.
Locke, Augustus,	Hampton, N. H.
McDougall, Wallace D.,	20 Bedford Place, Russell Sq., London, Eng.
McPherson, William B.,	415½ S. Spring St., Los Angeles, Cal.
Mayer, Paul H.,	13 Central Park W., New York, N. Y.
Moore, Roy W.,	P. O. Box 48, Velasco, Tex.
Munroe, Martin,	Bengal Coal Co., Murulidih, Mohada, B. N. Ry., Bengal, India.
Nelson, D. W. C.,	Baker City, Ore.
Nobs, Frederick W.,	Negociacion Minera Santa Maria de Guadalupe y Anexas, S. A., Minillas, Zac., Mexico.
Pearson, William R.,	628 W. 114th St., New York, N. Y.
Perks, Harry B.,	419 Board of Trade Bldg., Portland, Ore.
Prentis, Edmund A., Jr.,	Lluvia Oro Mine, Lluvia de Oro, Chih., Mex.
Rathborne, Merwyn R. W.,	Amargosa, via Las Vegas, Nev.
Rhew, James W.,	Cia. Minera y Exploradora de Ventanas, S. A., Ventanas, Dur., Mex.
Shaler, Millard K.,	Dobbs Ferry, N. Y.
Sheldon, Waldo,	Urique, Chih., Mexico.
Short, Frank R.,	Carson City, Nev.
Thornton, Edward T.,	Apartado 30, Matehuala, S. L. P., Mexico.
Twynam, Henry,	O. K. Copper Mine, Cairns, No. Queensland, Australia.
Watson, Ralph W.,	Calloo, Utah, Clifton Mail box.
Weddle, Joseph H.,	100 William St., New York, N. Y.

NECROLOGY.

The deaths of the following members were reported to the Secretary's office during the month of January, 1912:

Date of Election.	Name.	Date of Decease.
1890.	*Farrel, Franklin,	January 11, 1912.
1891.	*Hall, Harry R.,	December 11, 1911.
1892.	*Hartzell, H. K.,	——— —, ——.
1892.	*Hobson, John B.,	January 9, 1912.
1882.	*King, Thomas M.,	September 13, 1911.
1906.	*McLaughlin, William L.,	——— —, 1911.
1877.	*Meister, Herman C.,	November 27, 1911.
1898.	**Morris, James,	——— —, 1911.
1903.	*Saylor, Benjamin F. A.,	December 2, 1911.
1871.	**Squire, Joseph,	October 24, 1911.
1891.	*Touzeau, Edward M.,	November 15, 1911
1904.	*Wainwright, J. Howard,	December 29, 1911.

* Member. ** Life Member.

BIOGRAPHICAL NOTICE.

Francis Collingwood was born Jan. 10, 1834, at Elmira, N. Y., where he received, in the public schools and the academy of the town, his preliminary education. At the age of 13, he became an apprentice to the trade of watchmaker and jeweler, which he afterwards practiced for a few years. During this apprenticeship, however, he devoted the late evening and early morning hours to study in mathematics and engineering, and also managed to gain some experience as a rodman, so that, at last, he was able to enter the Rensselaer Polytechnic Institute, at Troy, N. Y., from which he was graduated as Civil Engineer in 1855, at the head of his class. Until 1869 he had a varied experience, comprising some railroad work in Wisconsin; an extensive private practice as surveyor, expert, and court referee (particularly as to masonry and hydraulic work) in Elmira; service for several years as the City Engineer of that town (during which he constructed its first permanent sewer); and, from 1857 to 1869, in addition to his other employments, the conduct of a jewelry business, coupled with the sale of scientific instruments. Early in 1869, he made the preliminary surveys for a railroad in Pennsylvania. In July of that year, he became Assistant Engineer on the Brooklyn bridge—the first suspension-bridge over the East River. This position he held for fifteen years, during which he was connected, more or less intimately, with all parts of that great, and, in many respects, novel work—more especially with the sinking and equipment of the caissons, and the construction of the towers and anchorages, and the New York approach and station. The last two are reported to have been built in all details essentially after his designs. Before leaving this work, he had prepared plans for warehouses, utilizing some of the arches under the New York approach.

In 1883–1884 Mr. Collingwood directed extensive repairs to the Allegheny suspension-bridge at Pittsburg, Pa., which had been endangered by the rusting of the cable-wires at the anchorages. He spent the summer of 1884 in Europe and the year after his return in regaining his health, impaired by previous arduous labors. In the autumn of 1885, he became a regular contributor to the *Sanitary Engineer*, to which he contributed many valuable articles on engineering subjects, especially on fire-proof construction. At this date, also, he established, as general consulting engineer, an office in New York City.

Mr. Collingwood's record of ability and integrity led to his appointment on many boards of inquiry, etc., and to his employment as designer or adviser in connection with many public works. Thus he was the supervising engineer of the building of the first wooden dry-dock at Newport News, Va.; a member of the New York Commission created to examine the construction of the Second Croton aqueduct; the engineer employed to design the "intercepting sewer" for Elizabeth, N. J.; and, early in 1895, he was appointed an expert civil-service examiner for the city of New York—a position which he occupied for many years.

Mr. Collingwood became a member of this Institute in 1882, and maintained to the end a lively interest in its proceedings and welfare, although his more intimate connection with the Society of Civil

Engineers naturally led him to give to the publications of that Society his professional communications. I find in our *Transactions* only one contribution from him—namely: "Remarks on Steel Castings" (*Trans.*, xiv., 357); but I am convinced by many personal proofs of his sincere and friendly sympathy with the Institute.

Mr. Collingwood was from 1873 to 1876, inclusive, a Director of the American Society of Civil Engineers, and from 1891 to 1894, inclusive, the secretary of that Society, which made him also, at various times, chairman or member of important technical committees; such as the committee on rapid transit, the report of which undoubtedly hastened the building of the elevated railroads in New York, and the committee for determining the linear compression of cements under various conditions of composition, age, and load. His contributions to the *Transactions* of the Society include professional papers on various departments of the construction of the Brooklyn bridge; wind-pressures; the preservation of forests, etc.; and remarks in discussion of the testing of cements, steel and iron, on the power of water to transport earth, etc. He contributed also in 1872, to the Franklin Institute of Philadelphia, a paper on combustion in compressed air: and in 1884, he presented to the Institution of Civil Engineers (London), of which he was a member, a paper on the repair of the cables of the Allegheny suspension-bridge (Minutes of Proceedings, etc., vol. 76, p. 334) for which he received (vol. 79, p. 223) the double honor of the Telford premium and the Telford medal.

In addition to other professional and official labors for the American Society of Civil Engineers, Mr. Collingwood endowed, in 1894, a prize for "Juniors" of the Society, to be awarded, under certain conditions, to a paper describing an engineering work with which the writer had been directly connected.

Besides the bodies already mentioned, he was an honorary member of the Rensselaer Engineers' Society; corresponding member of the American Institute of Architects and the Elmira Microscopical Society; and member of the New York Microscopical Society, the New York Academy of Science, and the Elmira Academy of Science (of which he was also one of the founders). Outside of professional and scientific connections, he discharged many duties, to which he was called by reason of the universal confidence and esteem with which he was regarded. At various times, he was School Commissioner in Elmira, Loan Commissioner of Chemung county, N. Y.; vestryman, Sunday-school superintendent or treasurer of churches in Elmira, Elizabeth, and New York City; treasurer of the Episcopal mission to seamen in the latter city, etc. During the latter part of his life, he resided at Elizabeth, N. J. He died Aug. 18, 1911, at his summer home, Avon-by-the-Sea, New Jersey.

To this imperfect sketch of a long, useful, and stainless career, I would add my personal testimony, based upon a cordial and unbroken, though not closely intimate, friendship of many years, to the personal worth and attractiveness of this modest, quiet, thorough engineer, and man—so charitable in judgment, yet so firm in integrity; so conservative, yet so sympathetic with the progress and the aspirations of "Juniors"; so serenely strong, yet so sincerely kind and deeply dear! R. W. R.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Black Mountain Coal-District, Kentucky.

BY J. B. DILWORTH, PHILADELPHIA, PA.

(San Francisco Meeting, October, 1911.)

I. INTRODUCTION.

THE purpose of this paper is, first, to give a general account of a little-known coal-district of SE. Kentucky, its topography, drainage, and mineral resources, for those who may be interested in its economic development; and secondly, so to describe the geologic features of the field as to furnish available data to those engaged on the broader problems of Appalachian coal-geology.

The data from which the major portion of the paper has been prepared were obtained, in professional investigations for private individuals and corporations, within the last decade.

The area under review, defined by a heavy line on the map, Fig. 1, lies between Little Black and Pine mountains, and extends from Harlan on the west to a N–S. line crossing Looney creek 3 miles from its mouth on the east. This area can be divided for description into a Western and an Eastern Division.

The character of investigation pursued in the Western Division, below Fugitt creek, was very different from that employed in the Eastern. In the former, only a rapid reconnoissance was attempted: such coal-openings as had been made by prospectors or by citizens in obtaining fuel were visited, their sections measured and, in many instances, sampled. Elevations were obtained barometrically and approximate locations sketched on a small-scale map.

In a field where the coals are so well opened, the reconnoissance method gives a very fair idea of the number and character of the principal beds and their relative positions, and affords much evidence for their correlation over wide areas, without permitting the more refined work required to discover all the seams of the measures and to determine the details of geologic structure.

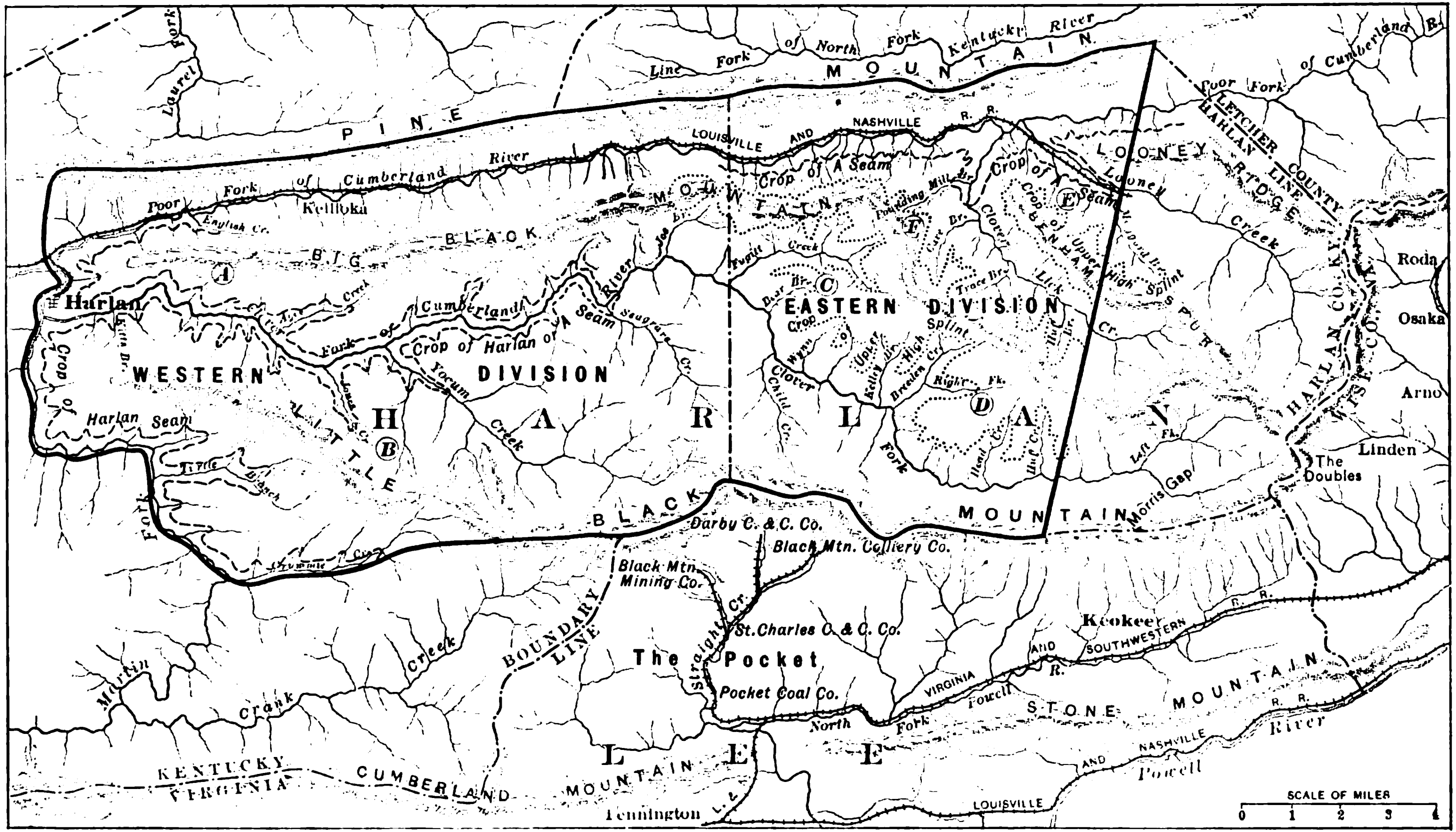


FIG. 1.—REGIONAL MAP, SHOWING POSITION OF THE BLACK MOUNTAIN COAL-DISTRICT, HARLAN, KY.

In the Eastern Division, the territory is largely owned in fee simple by one large corporation, which had it thoroughly prospected prior to the inauguration of mining-operations now in progress on Looney creek of Poor fork. The greater portion of this preliminary development was conducted by me while in the employ of E. V. d'Invilliers, geologist and mining engineer, of Philadelphia, to whom I am indebted for permission to use the data thus obtained. In this division about 350 coal-openings on 14 different seams were measured; many were sampled for chemical analysis, and most of them were located by stadia, to determine their exact positions and elevations, and to define the structure of the area. Complete geologic sections of outcropping strata were compiled at numerous points, the coal-seam intervals being determined from stadia-levels and the intervening strata being measured barometrically. The geologic features of this Eastern Division have been illuminated by recorded observations so numerous as to guarantee the general correctness of deductions and correlations made within the field.

II. General Description.

The Black Mountain coal-district, as here considered, is an area approximately 20 miles long by 8 broad, lying in Harlan county, Ky., and extending NE–SW. along the boundary between that State and Virginia. A glance at any map of the eastern United States will show that this district, with the adjoining territory to the north and northeast, forms the largest area east of the Mississippi river undeveloped by railroads and without navigable streams. Situated a short distance west of the Atlantic-Gulf divide on the rugged Cumberland plateau, it is far removed from the great industrial centers and markets of the Atlantic sea-board and the Mississippi valley, and peculiarly isolated from them by lack of both rail- and river-transportation. To this geographic isolation are due its sparse population, its industrial stagnation, and its practically undeveloped wealth of coal.

For many years the nearest railroad to the Black Mountain district was the Cumberland Valley branch of the Louisville & Nashville R. R., which followed the southern foot of the Cumberland and Stone mountains in Virginia from Middlesboro to

the town of Big Stone Gap, thence up the North fork of Powell river, 14 miles, to a connection with the Norfolk & Western R. R. at Norton. This line ran for a long distance within 10 miles of the coal-field, from entering which it was effectually barred, all the way, by unbroken mountain-ridges; and hence it added but little to the accessibility and value of the Kentucky field.

Similarly, in recent years, the railroad now known as the Virginia & Southwestern was built from Bristol and the southeast through Big Stone Gap to serve mines along the southern flank of Little Black mountain, but was never extended into Harlan county. This road passed close to the most important break in the Cumberland-Little Black Mountain barrier (Morris gap, just north of the mining town of Keokee); but owing perhaps to the absence of proven areas of thick coal on upper Clover fork, no attempt was made to enter the field by means of this gap.

In 1909, a considerable coal-territory west of Harlan, and also on upper Poor and Clover forks, was controlled by important interests, able and anxious to develop their holdings; and in the latter part of that year construction was begun by the Louisville & Nashville R. R. on a branch about 50 miles long, extending from Wasioto up the Cumberland river to Harlan, thence along Poor fork to Benham, the mining-plant of the Wisconsin Steel Co., 2 miles up Looney creek. This branch is now operating throughout its entire length.

Harlan, the county-seat, is the only village in this district. It has at present a population of but a few hundred. However, with the stimulus of the railroad and its advantageous location near the center of a large, virgin coal-field, it should become one of the more important towns of the region.

The area, as a whole, is sparsely settled. As the principal industry in the past has been farming, habitations are confined almost exclusively to the valleys, where the narrow bottoms and lower mountain-sides are under cultivation, leaving the long, steep upper slopes with much of their original forest covering.

From the forests the finer soft woods—poplar, lynn, ash, etc.—have been very generally cut and floated to the mills at Wasioto. But there still remains a vast amount of hard and

semi-hard timber—the various oaks, sugar-maple, hickory, beech, and chestnut—only awaiting the advent of railroads to become valuable.

III. Topography.

Topographically, the district is one of great relief, with deep, contracted valleys separated by lofty ridges, the result of stream-erosion of an ancient, elevated, base-leveled plane. No plateaus exist; and, without exception, the level land at the mountain summits is confined to a strip from a few feet to a few hundred yards in width.

The declivities are usually very steep; the slope for hundreds of feet frequently exceeds 30°. At certain horizons—notably near the bottom of the Harlan formation—massive sandstone strata outcrop as great cliffs, forming conspicuous features in the landscape, as well as valuable guides to the position of certain coal-beds.

Topography has an important bearing on the economic value of this area; for the high ridges expose an unusual thickness of coal-measures and carry several valuable beds available for cheap drift-mining. The valleys form natural avenues for the location of railroads to serve the mines.

Erosion has, of course, greatly reduced the original areas of the higher coals. From the sharp-crested character of the mountains it follows that the remaining areas of the several beds vary inversely as their heights above the main drainage-channels.

Pine mountain is one of the chief topographic features of the region. Marking a great fault-line, its upturned strata of hard sandstone and conglomerate rise northwardly from the valley of Poor fork at an angle of from 25° to 40° to a long straight crest more than 1,000 ft. above drainage. For 85 miles, from the Breaks of Sandy on the NE. to Pineville on the SW., no low gaps break this great mountain barrier. It is crossed by few roads; and it effectually separates the communities along Poor fork from those on Kentucky river to the north.

Big Black mountain, higher and even less passable than Pine, extends easterly from Harlan 40 miles to East Butte knob at the head of Poor fork, and forms the central divide, or "back bone," of the district. Throughout this distance it is from 3,000 to 4,000 ft. above tide, or 2,000 ft. above Poor and

Clover forks. It is crossed by several bridle-paths but by only one wagon-road—the highway from Stonega, Va., to Whitesburg on the Kentucky river.

Thus, until the advent of the railroad, the central Poor Fork valley, in the vicinity of Looney and Clover Lick creeks, was peculiarly inaccessible, and all freight was wagoned from Stonega—a distance of 25 miles—over roads almost impassable, except in dry weather.

Benham spur and Looney ridge are the only noteworthy laterals on the Kentucky side of Big Black mountain. They are separated by Looney creek, and have the same general character and elevation as the parent mountain.

Little Black mountain, the southern boundary of the district, extends 25 miles in an almost straight line from Harlan to its junction with Big Black at "The Double," the highest knob of the region, more than 4,100 ft. above sea-level. At the west it divides the Clover and Martin forks of Cumberland river; on the east, Clover fork and the North fork of Powells river. High and rugged west of Childs creek, it sinks, along upper Clover fork, to a comparatively low ridge crossed in two places by wagon-roads. The more important of these passes is Morris gap, just north of Keokee, 2,622 ft. above sea-level, 520 ft. above Clover fork, and 590 ft. above the railroad grade at Keokee. Through this gap passes all the hauling between the railroad and the upper Clover fork country.

The following are the approximate elevations of some prominent points in the Eastern Division, determined by stadia-surveys, based upon an Interstate Railroad bench-mark on the root of a maple 100 ft. north of the railroad station at Keokee, which bears the record of an altitude of 2,028.81 ft.—presumably above mean sea-level:

	Altitude. Feet.
Morris gap,	2,620
Clover fork, mouth of Left fork,	2,100
Clover, mouth of Huff creek,	1,945
Clover, mouth of Breeden creek,	1,680
Clover, mouth of Fugitt creek,	1,470
Summit Big Black, Fugitt-Pounding Mill trail,	3,330
Summit Big Black, Breeden-Trace trail,	3,470
Summit Big Black, Huff creek trail,	3,615
Clover Lick creek, mouth Huff branch,	1,820
Clover Lick creek, mouth Peal branch,	1,575
Clover Lick creek, mouth Pounding Mill,	1,460
Poor fork, mouth Clover Lick creek,	1,400
Poor fork, mouth Looney creek,	1,420
Looney creek, mouth Maggard branch,	1,535

IV. Drainage.

This feature of the district can best be understood by an examination of the map, Fig. 1. In the Western Division the drainage has been taken from the rather inaccurate "Jonesville" sheet of the U. S. Geological Survey; but in the Eastern Division the important streams were mapped from stadia-surveys, made in the course of the recent development-work.

The entire area is drained westwardly by the three head-tributaries of the Cumberland river—Poor, Clover, and Martin forks. To the north, beyond Pine mountain, the drainage flows in a northerly direction, and is carried to the Ohio by the widely-branching Kentucky river, while southward the Tennessee river receives the waters through its tributaries, the Powell and the Clinch.

Poor fork, heading against Pound river of the Big Sandy, follows an almost straight course along the foot of Pine mountain to the town of Harlan, where it joins Clover and Martin forks to form the main river. Though generally fordable, it has an abundant flow of water at all seasons, and meanders through bottoms averaging perhaps 0.25 mile in width, with a gradual fall of less than 1 per cent. Hence, a standard railroad could be constructed practically to its source; and many sites are afforded for mining-plants and saw-mills, to develop the great coal- and timber-resources of this section.

Looney and Clover Lick creeks, entering Poor fork 22 miles from Harlan, are its most important tributaries. Both are perennial streams with gradual fall and narrow bottoms for several miles up from their mouths, giving ready access to the extensive areas of flat, outcropping coal in the heart of the field.

Clover fork, about 30 miles long, occupies the geographical center of the Black Mountain district. While similar to Poor fork in rate of fall and valley-contour, it drains a larger portion of the area under review. It is farther from the zones of upturned strata, has more large tributaries than Poor fork, and affords access to a very large coal-territory available for the cheapest form of self-draining drift-mining.

Martin fork skirts the field for a few miles SE. of Harlan, and is of interest chiefly as rendering a considerable area of the valuable Harlan coal-seam accessible to inexpensive mining.

V. General Geology.

The Black Mountain district occupies the eastern end of the Cumberland Gap coal-field, an area of coal-bearing formations 90 miles long by 10 to 20 miles wide, on the eastern margin of the great Appalachian field. Immediately south lies the wide area of older, non-coal-bearing rocks forming the Appalachian valley, while north and northwest the almost level strata of the coal-measures stretch away for many miles towards the limestone "Blue Grass" region of central Kentucky.

The outcropping rocks of this coal-basin are all sedimentaries. On the evidence of their fossils, they have been assigned by the U. S. Geological Survey to the Pottsville Formation of the Pennsylvanian Series, at the base of the Coal Measures.

It is believed that the lowest strata here exposed—the Lee Conglomerate, forming the crest and southern slope of Pine mountain—are at the bottom of the Pottsville, and the highest rocks on Black mountain are near the top of that formation, giving it a total thickness in this field of over 4,000 ft. As most of the strata lie almost flat, and are well exposed on the steep mountain-sides, the district offers unusual opportunities for detailed study of the Pottsville in this, its greatly thickened southern extension.

The SW. continuation of this district—from Harlan to Middlesboro—has been mapped and studied geologically by the National and State governments[1] within recent years, and at a much earlier date (1887) by Messrs. E. V. d'Invilliers and A. S. McCreath.[2]

From Messrs. Ashley and Glenn's clear descriptions and numerous illustrations it has been easy to correlate the principal strata of the western field with those of the Black Mountain district, especially as the two areas overlap for a few miles just east of Harlan. The sub-divisions of the formation made by these observers have not been carried through the present description, but the limits of each are generally well defined, and are indicated on the suite of vertical geologic sections, Fig. 2.

[1] G. H. Ashley and L. C. Glenn, *Professional Paper No. 49, U. S. Geological Survey* (1906).

[2] *Resources of the Upper Cumberland Valley:* published report to Louisville & Nashville railroad (1887).

These sections were carefully compiled at points indicated by their headings and by letters corresponding with those on the accompanying regional map. In the case of those personally measured, intervals between coal-beds were deduced from stadia-locations and elevations, except the Jones creek section, where they were determined barometrically.

A glance at the geologic sections shows the strata to be sandstones and shales—with all intermediate grades of sandy shales and shaly sandstone; numerous coal-seams; and one thin, but geologically interesting, bed of limestone.

Sandstones largely predominate, especially in the upper part of the column, composing perhaps two-thirds of the total section above the Harlan, or *A*, coal. Though rarely conglomeratic, these beds are frequently coarse and massive, and form prominent cliffs on the mountain-sides, especially when underlain by softer, shaly strata, which disintegrate more readily and permit the massive beds above to break in great vertical faces.

The most noteworthy sandstone-formation in the district begins at the top of the heavy shale-bed carrying the Fossil limestone and extends upward about 800 ft. to the mountain-summits. This about corresponds to the Harlan sandstone of Campbell.[3]

The lower 300 ft., in which occur the three High Splint coals, is particularly massive and forms the bold, gray cliffs so conspicuous on upper Clover and Poor forks along the brows of Big Black mountain and Benham spur.

Another sandstone-formation of geologic interest lies between the Harlan (*A*) and the *B* coal-beds. It has been correlated by Campbell with the Gladeville, a widely recognized key-rock in the Virginia area to the south and east; but in the light of recent developments it seems probable that this formation is much nearer the Lee conglomerate than the Gladeville sandstone of his section. It is approximately 130 ft. thick, massive sandstone at top and shale or shaly sandstone at middle and bottom. The prominent outcrop of the sandstone member may be traced from Harlan, where it is more than 500 ft. above drainage, up Clover fork to Wynn branch. There it sinks

---

[3] M. R. Campbell, *Bulletin No.* 111, *U. S. Geological Survey* (1893).

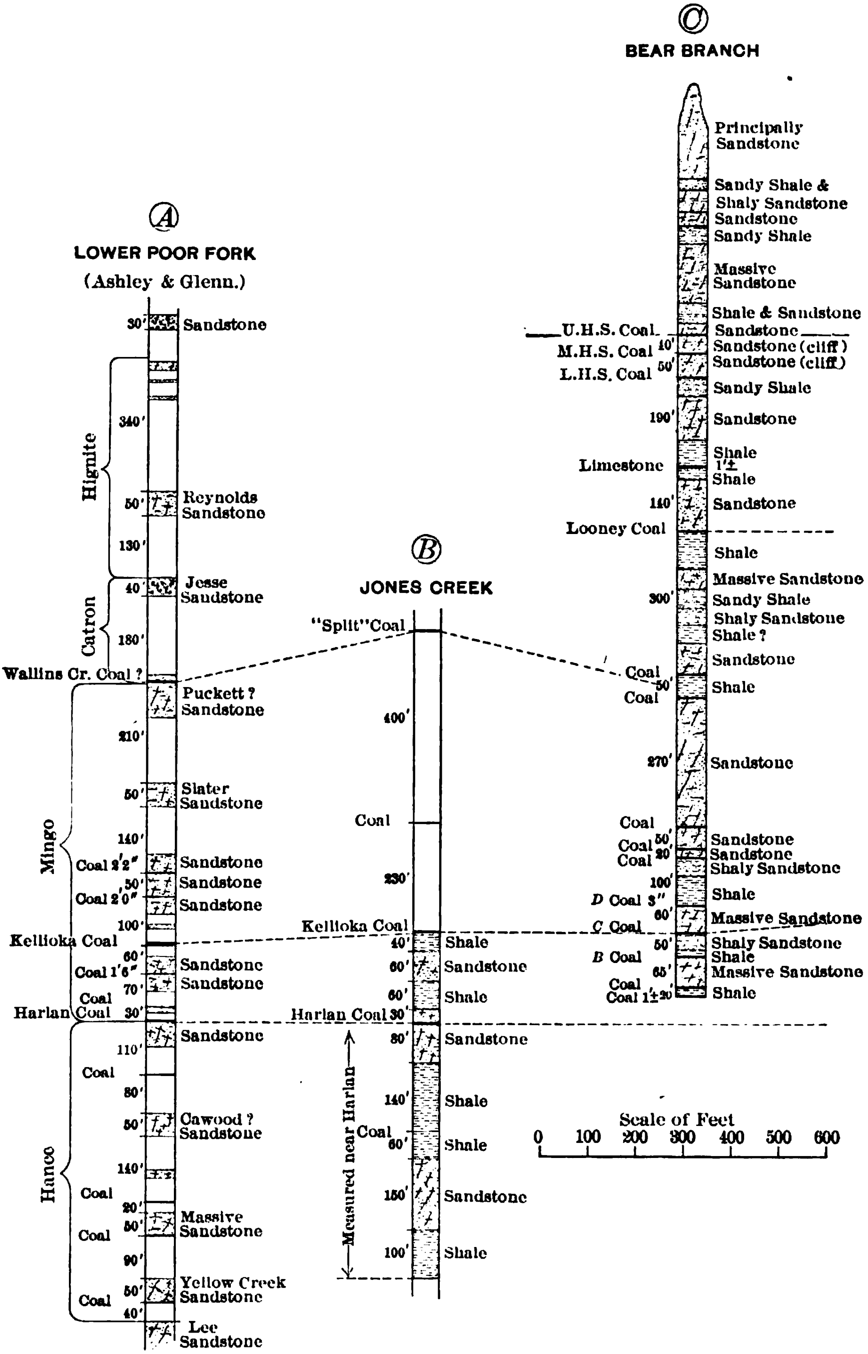
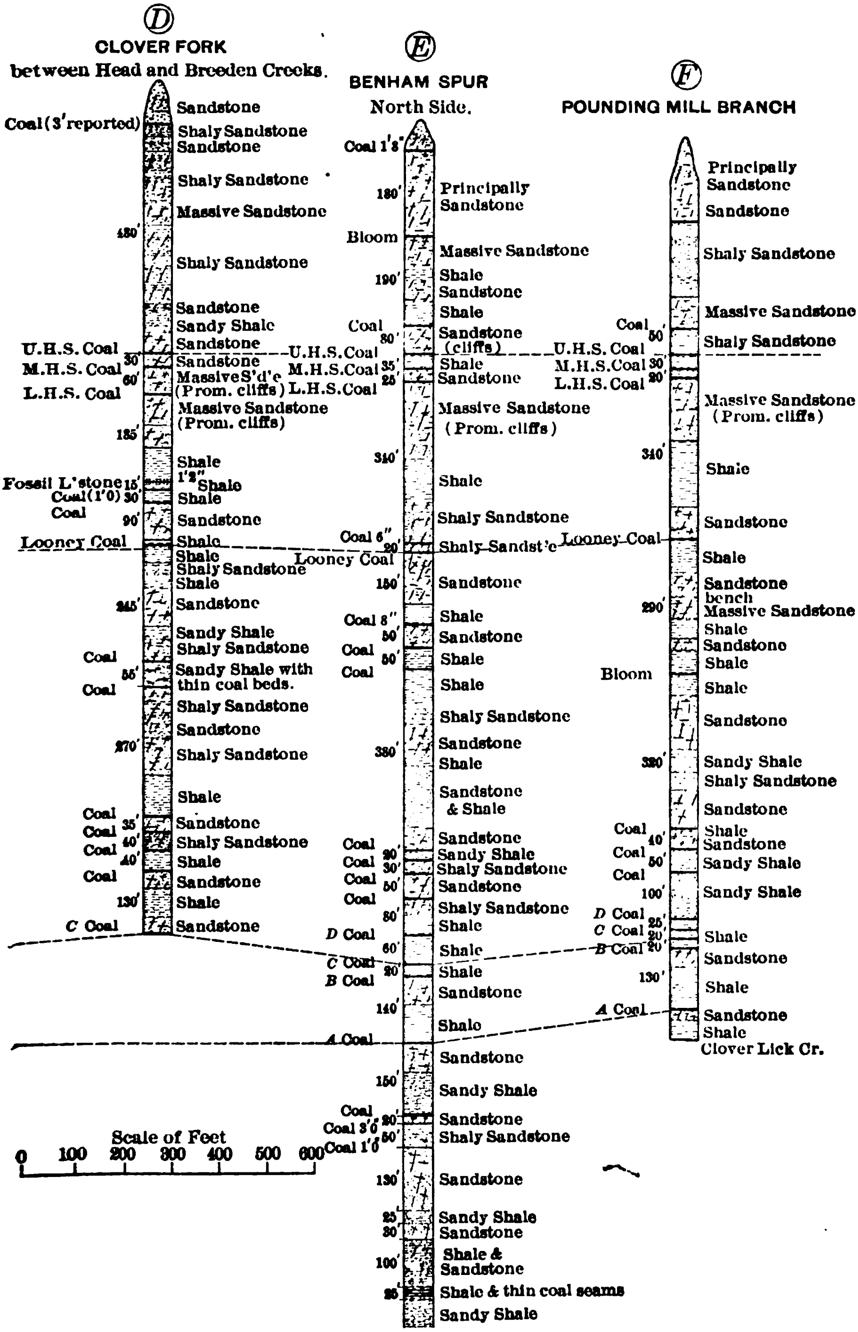


Fig. 2.—Comparative Geologic Sections,

[10]



BLACK MOUNTAIN COAL-DISTRICT.

beneath drainage, but, rising eastwardly about with the stream, it reappears below Head creek and forms the valley-bottom, to and above the Left fork. Its position in the upturned strata along the south bank of Poor fork is not so easily determined; but it is well developed on the Clover Lick and Looney tributaries of that stream.

Persistent shale-beds are rare in these measures. The most prominent noted is in the eastern part of the field, where it occupies an interval of about 100 ft. between the Harlan sandstone above and a rather persistent sandstone—possibly the Reynolds of Ashley and Glenn—below. The rock is a soft yellow and gray shale, much less arenaceous than the prevailing rocks of the district.

The only known limestone stratum outcropping in this region occurs near the bottom of the above-mentioned shale-formation, where it was seen at several places on upper Clover fork. A dark, impure bed about 1 ft. thick, it is remarkable for its abundance of fossil shells; but unfortunately only a small sample of the rock was obtained, and no careful study of its fossils has yet been made. This unique bed, if persistent, should give great assistance in correlating the strata of this district with those of Wise and Dickenson counties, Va.; for though it is thin, and occurs high in the hills, its peculiarities render it conspicuous, and many of its outcrops are known to the keen-sighted mountaineers.

Correlation in this region is difficult, by reason of the absence of any prominent and persistent key-rock. The massive sandstones frequently become shaly and insignificant or entirely disappear in short distances; the shale-beds are few and variable; and even the coal-seams—perhaps the best guides—can only be exposed by great labor and expense, and then vary between wide limits in section and interval. The great variability of the lower strata outcropping near the general drainage-level is well illustrated in the geologic sections, Fig. 2, where little harmony can be distinguished in the strata below the Looney coal-seam.

The coal-beds, to which this region largely owes its economical value, will be discussed in a separate chapter, after a brief consideration of the geologic structure of the field.

VI. Structure.

The Cumberland Gap coal-field is structurally a great trough or syncline, lying between the Pine mountain fault and the Powell valley anticline. The axis of this Middlesboro syncline, as it has been called, or the central line towards which the measures on either side dip, lies near the northern or Pine mountain side of the field, and closely follows Big Black mountain from Harlan to the head of Fugitt creek.

In the Western Division the strata on both banks of Poor fork, along the northern margin of the syncline, are sharply upturned, but flatten rapidly to the south as they approach the center of Big Black mountain. Along Clover fork, which drains the heart of the basin, the beds lie almost flat, having a northward inclination so slight as to require an instrumental survey for its detection.

Only in the Eastern Division were the locations of outcrops sufficiently accurate to permit a detailed exposition of the structure. The axis was found to follow a sinuous course, coincident with upper Fugitt creek; thence to extend eastward, crossing Clover Lick creek at the mouth of Cave branch, and cutting diagonally across Benham spur to intersect Looney creek about 5 miles from the river. In this distance the axis shows a decided pitch to the west, falling about 0.5 per cent., or 200 ft. in the 8 miles.

The measures along Poor fork dip southeast at angles of from 20° to 30°. The steep dips extend about 0.5 mile south from the river; then the beds flatten quickly to an almost horizontal position.

This 0.5-mile zone of upturned strata on the south side of Poor fork seems to follow closely that stream and to be independent of the position of the axis. On upper Fugitt creek, it is within 0.75 mile of the axis, towards which the strata dip somewhat rapidly, while on Looney creek the two have swung more than 2 miles apart and are separated by a wide area in which the average dip is about 2 per cent.

South of the axis the dips are somewhat irregular in direction and intensity, but never sharp. A subordinate trough appears to branch from the major one about central Fugitt creek, and to pursue a SE. course to the mouth of Breeden creek, with

gentle dips, averaging less than 2 per cent. The beds lie almost flat in the Big Black mountain between Fugitt creek and Trace branch. The valley of middle Clover Lick occupies another minor trough of the main basin. From Breeden creek eastward to Huff creek the rise is irregular in direction and much more rapid, averaging about 3 per cent.

The structure of a coal-field is an important economic feature, since only with a knowledge of the direction and magnitude of bed-inclinations and the position of the major lines of elevation and depression can mines be properly laid out. Other conditions permitting, a mine should enter the coal at the lowest point of the area to be worked, that grades may be in favor of the loaded cars, and the drainage may be handled by gravity.

Several such favorable points of attack present themselves in this field, where gentle dips are the rule, and the principal beds are above drainage and suitable for cheap drift-mining.

VII. Geology of the Coals.

The geologic sections previously mentioned show the large number of coal-seams exposed in the 2,000 ft. of strata outcropping between the base and summit of Big and Little Black mountains, and indicate the relative stratigraphic position of each. They aggregate almost a score, of which about half have commercial value in individual parts of the field. Commencing at the lowest, these coal-beds will be discussed in ascending order, and from west to east, giving them the names by which they are known in their field of best development.

In the Lee Conglomerate, coal-seams are known to occur, but they are sharply upturned and economically worthless, and therefore will receive no consideration here.

In the several hundred feet of strata between the Lee and bed *A*—exposed along Poor fork and around Harlan—no coals of importance are known. On lower Martin fork, a bed from 2 to 3 ft. thick, about 220 ft. beneath the Harlan, or *A*, seam has been opened in a few places; and along the south side of Poor fork, below Clover Lick creek, a coal apparently 50 ft. higher in the measures shows a generally thin and worthless section.

The absence of thick coals in this interval is of interest mainly as indicating that the famous Imboden seam of Wise county, Va., which occurs in this horizon, has deteriorated northward and either vanished or become insignificant in the Poor fork area.

The Harlan seam—or bed *A*, as it is named on upper Poor fork—is the lowest commercially-workable bed of the district, and the most valuable. It will furnish for many years practically all the tonnage won from the western ends of Big and Little Black mountains; and in the eastern end of the field it shows a good mining-section for a number of miles along Poor fork and tributary creeks. This seam, the outcrop of which is indicated by a dash line on the map, Fig. 1, has been opened extensively on lower Poor, Clover, and Martin forks, where it crops from 400 to 500 ft. above drainage, yet has more than 1,000 ft. of cover and underlies a large area in the Black mountains. West of a meridian line through the mouth of Jones creek, it shows a clean, uniform 4-ft. mining-section, below which is sometimes found another 18 in. of coal separated from the upper by several inches of shale. East of this line, along Clover fork, the bed is seriously contaminated by shale partings, and has been sparingly opened until it approaches water-level, 14 miles from Harlan. Here it presents a more attractive section, showing 3 ft. 6 in. of clean coal where it goes under the river just above the mouth of Seagrave branch.

Above this point the Harlan (*A*) seam does not outcrop on Clover fork, but, rising eastward almost as rapidly as that stream, its horizon is never far below water-level—perhaps 20 ft. at the mouth of Fugitt creek, and 120 ft. at the mouth of Left fork, near Morris gap.

At Keokee, on the south side of Little Black mountain, it shows 7 ft. of coal with 15 in. of shale about 1 ft. from the floor, and is mined as the "Wilson" seam.

Along the main valley of Poor fork throughout the Eastern Division, bed *A* outcrops well above the stream, usually near the southern edge of the zone of upturned strata. In this area it exhibits a great thickness (12 ft. in some places), but the upper portion is usually slaty. However, below Looney creek the mining-section averages from 4 to 5 ft. thick, and will eventually yield a large tonnage. Above that stream the bed

is apparently split into two benches, neither of which is especially valuable.

Bed *B*, lying 140 ft., more or less, above the Harlan, has no importance in the Western Division. It has been doubtfully recognized at an opening 3 miles up Yocum creek on the north side, showing 3 ft. 4 in. of coal interspersed with 1 ft. of shale, and is again seen with similar sections at openings on either side of Clover fork, 1.25 miles above Seagrave branch.

In the Eastern Division this is the most persistent though not the most valuable of the lower seams. Along Clover fork it is generally too thin or carries too much intercalated shale to be commercially important. Lying 120 ft. higher than the river at Fugitt creek, and very impure, it is opened where it goes beneath drainage 0.5 mile above Wynn branch, showing 3 ft. 6 in. of coal with two 5-in. partings in the upper half. But 4 miles further up stream it appears with a 2 ft. 2 in. section, and is frequently opened close to water-level from there to the mouth of Left fork, usually showing a thick section of alternate shale and coal benches, the latter generally too thin to mine.

There is an exceptional exposure of bed *B* in a country-drift, just above Head creek, where it measures 9 ft. 6 in.; the mining-bench, 4 ft. 3 in. thick, is at the bottom, with a 6-in. shale parting 9 in. from the top.

In Looney ridge and Benham spur this seam attains its best proportions, averaging about 3 ft. 6 in. of practically clean coal. Its outcrop extends more than 4 miles up Looney creek and 3 miles up Clover Lick, offering large areas, very accessible to drift-mining. Numerous openings along the foot of Big Black mountain for several miles below Clover Lick creek indicate no value for the bed in that section.

Bed *C*—the Kellioka of Ashley and Glenn [4]—occurs approximately 30 ft. above the *B* seam. Geologically the most interesting seam of the field, because of its great areal extent and local peculiarities of bed-section, it is also, in certain localities, one of great commercial value.

Around Harlan this coal lies high in the mountains and has been but sparingly opened, as the more accessible and probably thicker Harlan, or *A*, seam supplies most of the local fuel.

[4] *Professional Paper No.* 49, *U. S. Geological Survey* (1906).

Passing eastward to Jones creek, where the *A* seam begins to deteriorate, bed *C* has been opened frequently; and on Jones, lower Yocum, and Bailey creeks it shows a mining-section from 3 ft. 6 in. to 4 ft. thick, occasionally overlain by shale carrying thin layers of coal. In this area, embracing several thousand acres in Big and Little Black mountains, the *C* coal is better than anywhere else in the Western Division, and redeems a section practically devoid of other commercial beds.

Ascending Clover fork its horizon gradually approaches the stream; sinks beneath it 0.75 mile below Breeden creek; reappears for a few hundred yards at the mouth of that creek; again emerges 1.5 miles further east, and stays close above drainage from there to and beyond the Left fork.

Scattered openings in this bed along Clover fork from Seagrave to Huff creek generally show a mining-section less than 3 ft. thick, sometimes overlain by a bench of shale and shaly coal, and occasionally by cannel or cannel slate—as at openings 0.5 mile up Fugitt creek, and on the south side of the river below Joe branch.

Above Huff creek, bed *C* shows a thickening section and loses its shale partings, until openings near Morris gap and opposite Keokee show over 5 ft. of practically clean, good coal. This condition is apparently maintained over large areas to the south and east; for the *C* seam is certainly the principal bed mined at Keokee (there called the McConnell) and most probably the Taggart, worked at Roda in Wise county, Va. At both of these mines it is from 5 ft. to 6 ft. 6 in. thick. In the Pocket district of Virginia it is probably this seam which is mined as the Darby, and shows from 2 ft. 6 in. to 3 ft. 6 in. of clean coal.

In Looney ridge and on the east side of Benham spur, bed *C* attains its greatest development in the Black Mountain district. Throughout this area it is uniformly a seam of the highest commercial value, averaging 5 ft. 6 in. in thickness, and practically without partings.

In Benham spur a remarkable and geologically interesting feature is presented in connection with this bed. In tracing its outcrop around the nose of the spur, a small shale parting near the center of the section is first observed at an opening near the mouth of Looney creek; in a few hundred yards this

parting has swelled to 1 ft.; and when Clover Lick creek is reached the two coal-benches are separated by from 20 to 50 ft. of sandstone and shale, the former very massive and making prominent cliffs along the creek. This great parting has but slightly altered the usual 80-ft. interval between beds *B* below and *D* above; consequently the lower bench of *C* is found within a few feet of *B*, and the upper bench close under *D*.

This split condition of bed *C* obtains on both sides of Clover Lick creek, and probably extends down Poor fork several miles. It is believed that the two benches unite under Big Black mountain, to form the comparatively thin seam identified as *C* on Clover fork.

Bed *D* is an insignificant and rarely-observed seam, except along Looney and Clover Lick creeks of Poor fork. No openings at its horizon were noted in the Western Division, and on upper Clover fork it shows only a few inches of coal.

Along lower Looney creek it lies 50 ft., more or less, over *C;* but on Clover Lick, where *C* is split by a great parting, the interval between *D* and the upper bench of *C* varies from 10 to 35 ft. It averages about 3 ft. 6 in. of clean coal at the many openings made, indicating large commercial areas in Looney ridge and Benham spur. Throughout this part of the field the seam is characterized by a stratum of slate and coal one or more feet thick, lying just under the main mining-section.

The next coals to be noted in ascending the geologic column are a group of four beds occurring within a vertical interval of 120 ft., the lowest of which is about 130 ft. above the *C*, or Kellioka, seam. All are too thin to deserve more than passing notice.

In the Western Division a few scattered openings have been made in one or more of these beds; but it is impossible to correlate them definitely by reason of their similar thin sections and the small interval between them. To this group belongs the Creech (?) coal of Ashley and Glenn.[5]

Extensive prospecting in the Eastern Division has disclosed one or more of these four seams in numerous places; all four may be seen close to drainage on Breeden creek, near the mouth of Right fork.

[5] *Professional Paper No.* 49, *U. S. Geological Survey* (1906).

The bottom bed is very persistent, and wherever opened shows about 2 ft. of clean coal. The second is some 40 ft. higher, and while showing a 3 ft. 4 in. mining-section on Looney ridge, it is generally of no value. The third is about 40 ft. still higher, and is worthless. The fourth, at the top of the group, has been recognized principally along Clover fork above Breeden creek, where it is mined at a few country pits. This seam, or the one next below, represents the so-called "Low Splint" bed, of regional extent and commercial thickness on the south side of Little Black mountain in Virginia.

Mention may be made of an opening three-quarters of a mile up High Bank branch, a small tributary entering Poor fork 6 miles below Clover Lick creek. The seam here exposed lies about 300 ft. above *C* and is locally known as the "11-foot cannel bed." In reality it consists of 7 ft. of cannel-slate or highly-bituminous shale, worthless for fuel, parted 2 ft. 10 in. from the roof by 4 ft. 4 in. of black shale, and underlain by another foot of that material. At no other place was this seam observed; it is evidently a locally bitumenized shale-bed.

The Wallins creek coal, which attains such fine proportions on the stream of that name below Harlan, is represented in the Western Division of this district by a thick seam, sparingly opened high on the flanks of the Black mountains. It lies about 600 ft. above the Kellioka, or *C*, seam.

In the head of Kitts branch, entering Clover fork 2 miles above Harlan, this bed shows an upper bench of 4 ft. 4 in. of coal with a 6-in. shale parting 8 in. from the floor, and a lower 1 ft. 2 in. coal-bench separated from the upper by 1 ft. 4 in. of shale, coal, and bone. On the left prong of Turtle branch it measures 4 ft. 8 in. of clean coal.

In the Eastern Division, near the Wallins creek horizon is usually found a mass of shales carrying two or more thin coal-beds (see geologic sections, Fig. 2). On upper Childs creek, the two seams are 15 ft. apart, the upper being 4 ft. 4 in. and the lower 3 ft. 11 in. thick, and both somewhat impure. They are again exposed near the mouth of Breeden creek, where one opening shows 3 ft. 9 in. of coal with 5 in. of shale; but elsewhere this horizon has afforded no coals approaching commercial character.

The remaining coal-beds to be considered lie high in the

mountains; their outcrops are rather inaccessible and have been rarely opened, to supply local fuel-requirements. Consequently there is no knowledge of them in the Western Division, where they underlie relatively small areas, and can have but little economic significance.

The Looney bed, the lowest of these, is named from Looney ridge, its area of best development in the Black Mountain district. This seam occurs approximately 850 ft. above bed *C* and 135 ft. below the fossil limestone (page 160), and is probably equivalent to the Parsons seam of Wise county, Virginia.

In the high knob of Little Black mountain, at the heads of Yocum, Childs, and Straight creeks, the Looney seam has been opened in several places and shows from 4 ft. to 5 ft. 6 in. of coal, usually parted by a little shale. In Big Black mountain it is generally thin and worthless, though a limited area between Bear and Kelly branches will average 3 ft. of clean coal.

On the south side of Benham spur, it shows only a few inches of coal, but thickens northward until, in Looney ridge, a clean 5-ft. section is displayed.

The coals of the High Splint group are the highest and last beds to be mentioned; for though a few "blooms" or outcrops of beds have been noted in the 500 ft. of strata between this group and the mountain-tops, nothing is known of their character; and they are too inaccessible and too limited in area to have present commercial value.

The Lower High Splint bed lies from 300 to 350 ft. above the Looney seam, separated from the Middle by 30 to 60 ft. of rock—along Clover fork usually a bold cliff-making sandstone. It varies greatly in bed-section. Valueless in Looney ridge and Benham spur, this seam shows in Big Black mountain more than 3 ft. of minable coal, frequently overlain by from 2 to 3 ft. of slate and coal in alternate thin benches.

The Middle High Splint bed, 30 ft., more or less, beneath the Upper, is a quite clean and persistent, though uniformly thin seam, averaging about 3 ft. in Big Black mountain and somewhat less in Benham spur.

The Upper High Splint bed occurs uniformly 400 ft. above the Looney, and is by far the most valuable of the high seams in the Black mountains. It is known to exist with splendid section over large areas east of this district, and, though rather in-

accessible to mining-operations, will undoubtedly supply a large tonnage of superior gas- and domestic fuel. Its approximate outcrop is delineated on the map, Fig. 1.

The seam lies too high above drainage to have any appreciable area in Little Black mountain. Big Black mountain, by reason of its superior height and its position near the axis of the coal-basin, contains the largest and most important area of Upper High Splint in the district. It outcrops from 1,000 to 1,300 ft. vertically above the valleys of Clover and Poor forks.

In the eastern portion it averages about 6 ft. of coal, devoid of serious partings. Westwardly its section diminishes somewhat, and numerous measurements on Fugitt and neighboring creeks average slightly less than 4 ft. of clean coal. That the seam again thickens below this area is indicated by an opening on Joe branch, showing 9 ft. 5 in. of coal with a 6-in. shale parting 1 ft. from the floor. However, it is near the mountain-tops here, and probably underlies no important areas west of this point.

Benham spur carries a good acreage of this bed averaging over 4 ft. in thickness. Its condition in Looney ridge is unknown, as the portion of that mountain high enough to carry appreciable areas of the High Splint beds lies east of the field under review.

VIII. Character of the Coals.

Chemically, the coals of the Black Mountain district are very pure, high volatile gas- and coking-fuels, as evidenced by the proximate analyses, given in Table I. The samples affording these analyses were taken from outcrop openings by cutting a uniform amount of material from top to bottom of the bed, excluding only such slate partings or coal-benches as should be discarded in mining. They were very generally obtained from freshly-prepared faces under solid roof, where the coal was hard, clean, and lustrous. The resultant analyses should fairly represent the regional quality of the seams; and, except for excessive moisture in some instances and a slightly-diminished sulphur-content, due to leaching, they should be quite comparable with those made from mine-samples.

TABLE I.—*Coal Analyses: Black Mountain District, Harlan County, Ky.*

Bed.	Division.	Water.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Phosphorus.
A, or Harlan[a]	Western	1.48	38.53	57.56	3.91	0.87	0.0039
A, or Harlan[b]	Eastern	1.23	39.19	54.72	6.09	1.27	0 0037
B[c]	Eastern	3.32	38.72	57.95	3.33	0.65	0.0057
C, or Kellioka[d]	Western	1.57	38.41	58.89	2.70	0.64	0.0032
C, or Kellioka[e]	Eastern	3.42	38.79	58.92	2.29	0.65	0 0036
D[f]	Eastern	1.51	36.06	53.73	10.21	0.79	0.0195
Looney[g]	Eastern	4.28	38.67	53.40	7.93	0.95	0.0080
Lower High Splint[h]	Eastern	4.82	38.79	57.19	4.02	0.76	0.0090
Upper High Splint[i]	Eastern	4.92	38.85	56.82	4.33	0.65	0.0200

a. Average analysis 21 samples.
b. Average analysis 6 samples.
c. Average analysis 16 samples.
d. Sample from Yocum creek.
e. Average analysis 17 samples.
f. Average analysis 13 samples.
g. Average analysis 3 samples.
h. Average analysis 7 samples.
i. Average analysis 11 samples.

A striking feature of Table I. is the marked similarity in analyses of coals from widely-separated geologic horizons. It will be noted that the *B* and Upper High Splint beds, 1,300 ft. vertically apart, yield fuels of almost identical chemical composition.

The comparatively high ash found in the *D* and Looney beds is perhaps due rather to small slate binders included in the sample than to any inherent difference in the coal itself. The generally low percentage of ash and sulphur in the principal seams is noteworthy and adds greatly to their commercial value. Ash is remarkably low in the *C*, or Kellioka; its percentage in 18 samples falls between 1.45 and 4.25, classing this bed with the purest coals known.

Considering the seams as a whole, they are typical gas-coals in chemical composition; high in volatile hydro-carbons essential for the manufacture of illuminating-gas; low in the harmful ingredient, sulphur, and exceptionally free from earthy impurities.

As domestic and steam-fuels they should rank high. Their hardness, ease of ignition, low ash, low sulphur, and high calorific power are all features which will commend themselves to consumers. Calorimeter-tests of carefully-selected samples

from the more important beds showed about 14,000 B.t.u. per pound of coal.

Coking-tests of crushed coal from the lower seams have given very satisfactory results, as was to be expected, since the Roda and Keokee plants, operating the *C* seam in Virginia, manufacture a highly-valued metallurgical coke.

Physically, the coals of this district are hard, lumpy, and of the block type, similar to those of the Kentucky River and Elkhorn fields. Characterized by marked vertical cleavages, they mine in large, smooth-faced blocks, very different from the softer, columnar coals of the Pocahontas and New River districts in West Virginia, and better adapted to shipment and domestic use. In the Eastern Division of the district, the major cleavage-planes, or "faces," have a uniform direction of about N. 65° E.–S. 65° W.

Two varieties of coal, quite different physically, are found in varying proportions at almost every exposure in the field. One is a hard, dull gray splint that occurs in layers varying in thickness from a fraction of an inch to a foot or more. The thicker layers are exceedingly tough and hard, mining in large blocks which themselves break with a conchoidal fracture into sharp-edged fragments.

The other is a softer, black, lustrous variety, which breaks readily into small cubical pieces. It mines more easily than the splint; is less difficult to crush, and is more typically a coking-coal.

No one bed is all splint or all coal of the softer variety; neither do any two openings, even in the same seam, show the same proportion of these constituents. But, as a rule, more splint is found in coals of the High Splint group, the gas- and domestic fuels, than in the lower beds, *A–D*, which are more truly the steam- and coking-seams.

IX. General Correlations.

After the foregoing details of the several coal-beds of the district, some brief suggestions of their relations to other well-known seams in neighboring fields are pertinent. General vertical sections of the measures exposed in these fields are shown graphically in Fig. 3.

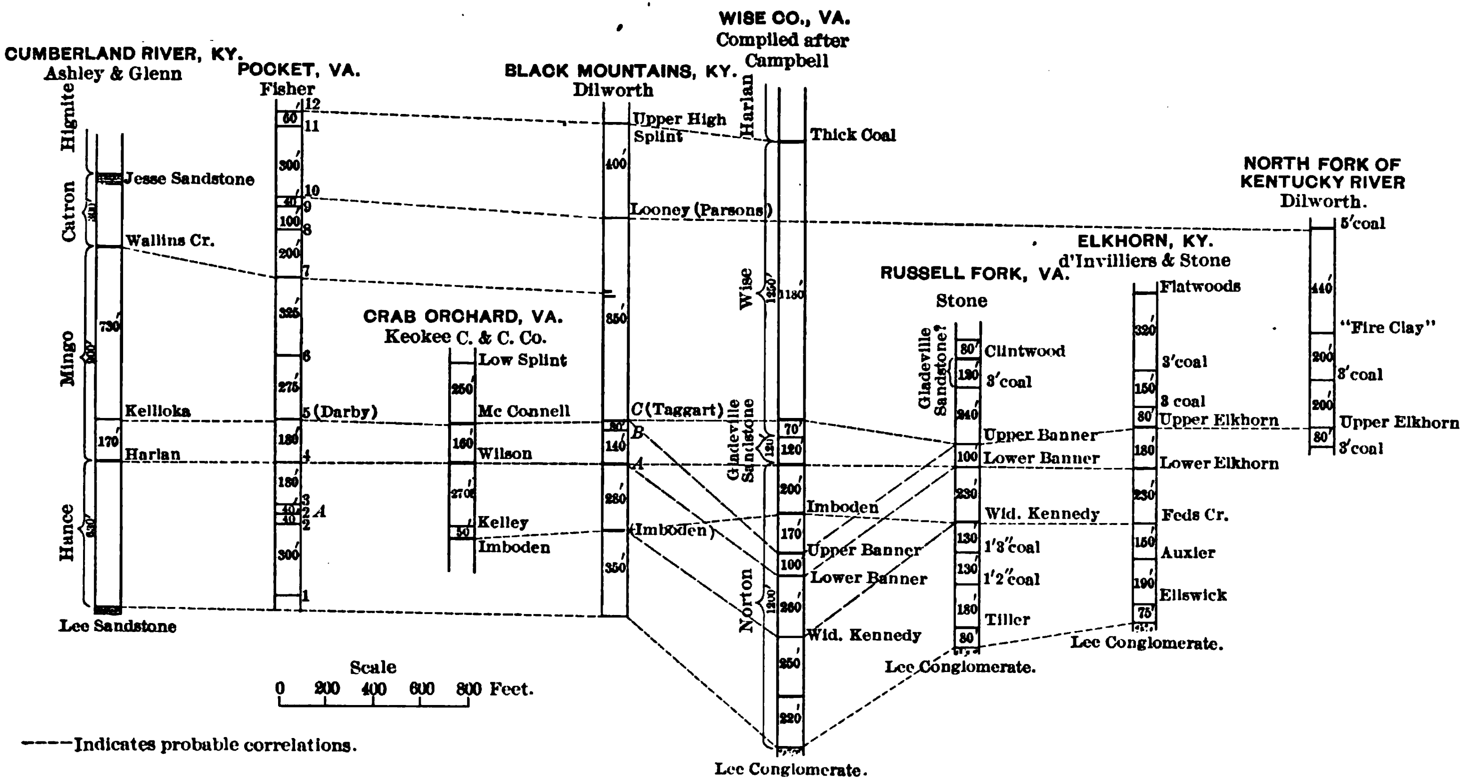


FIG. 3.—COMPARATIVE GEOLOGIC SECTIONS, SUGGESTING CORRELATIONS.

As already remarked, there is no difficulty in correlating the coals of the Black Mountain district with those of the territory to the west, where the important *A* and *C* beds are represented by the persistent Harlan and Kellioka seams.

To the south, in the Pocket district, Virginia, the identification of the Darby, or No. 5 seam of Fisher,[6] as bed *C*, is substantiated by a comparison of general geologic sections on either side of Little Black mountain; by the relative elevations of outcrop openings; and by the character of the seam in each locality. The equivalency of No. 10 and Looney, and of No. 12 and Upper High Splint, is similarly indicated.

In the Crab Orchard district, just east of the Pocket, the two principal coals, Wilson and McConnell, are, in all probability, the representatives of beds *A* and *C*.

The territory to the east, in Wise county, Va., was investigated by E. V. d'Invilliers and A. S. McCreath before the advent of railroads; and again by M. R. Campbell,[7] of the U. S. Geological Survey, a couple of decades ago, when it was sparingly developed, and the poorly-exposed geologic horizons were traceable only with great difficulty. The northwestern portion of Mr. Campbell's field of investigation overlaps the present one, but it is difficult to harmonize the results obtained in each. From his descriptions it is evident that coals he finds just above and below the "Gladeville Sandstone" on (Big) Looney and Clover Lick creek are beds *A* and *B*. It is also evident that his thick coal at top of the Wise formation is the Upper High Splint.

Developments of the Virginia Coal & Iron Co. in Wise county, Va., whereby the outcrops of the High Splint (Upper, probably), Parsons (Looney), Taggart, and Imboden seams have been traced over large areas, render almost certain the identity of *C* and Taggart, or Roda, coals, and place the Imboden seam 450 ft. below this horizon, or 280 ft. under bed *A*, about where Campbell locates it. Thus far there is seen to be a close agreement between Campbell's general section and the one given for the Black Mountain field.

The great discrepancy appears upon comparing the interval he found between the Imboden bed and the Lee Conglomerate

---

[6] Cassius A. Fisher, *Bulletin No.* 341, *U. S. Geological Survey* (1907).

[7] Marius R. Campbell, *Bulletin No.* 111, *U. S. Geological Survey* (1893).

with that deduced from Messrs. Ashley and Glenn's measurements[8] in the Black Mountain field. The former made it 1,000 ft.; the latter, 350 ft.

Considering now that portion of the geologic section just over the Lee Conglomerate, we find both Mr. Campbell and Mr. Stone[9]—the latter working in the NE. extension of the Wise County field on Russell fork waters—locating the Kennedy bed 500 ft., more or less, above the Lee, with the Lower and Upper Banners respectively 250 and 350 ft. still higher in the measures. The correlation of these beds with the Imboden, *A*, and *C* (or *B*) seams of Harlan county suggests itself.

To harmonize the correlations deduced as above, it is suggested that the coal Campbell called the Imboden (and clearly recognized only in the central portion of his field) might be the same as the Kennedy bed (recognized only in the eastern portion), and that an error was made in connecting the geology of these two divisions of his territory.

It would follow that the Gladeville sandstone lies between the two Banner coals, or, if it be about 370 ft. above the Upper Banner, as shown in Campbell's section, the sandstone called by that name on Poor and Clover forks really lies that distance below the true Gladeville horizon.

In the Elkhorn, Ky., field, north of Pine mountain, correlations may be made as indicated on the plate of sections, Fig. 3, using the Lee Conglomerate, as located by Mr. Stone, as a base. The coal-bed intervals shown in the Elkhorn general section apply particularly to the Marrowbone district, a part of the field prospected in great detail some years ago by E. V. d'Invilliers, of Philadelphia, Pa.

The last general section represents the measures on the North fork of the Kentucky river, between its head and Hazard, the county-seat of Perry county, and was compiled barometrically several years ago by me. Strangely enough, it bears but slight resemblance to the geologic section of the Black Mountain district immediately south. Though the two areas adjoin, the various geologic horizons cannot be traced from one to the

[8] G. H. Ashley and L. C. Glenn, *Professional Paper No.* 49, *U. S. Geological Survey* (1906).

[9] Ralph W. Stone, *Bulletin No.* 348, *U. S. Geological Survey* (1908).

other, by reason of the great strata-displacement resulting from the intervening Pine Mountain fault. However, certain correlations are suggested on the plate of sections, carrying identification via the Russell Fork, Va., and Elkhorn, Ky., fields.

Reviewing the correlations here advanced for one of the principal coal-seams in the Black Mountain and adjoining fields, it seems most probable that the *A* bed of Looney and Clover Lick creeks of Poor fork is the Harlan of Ashley and Glenn; the No. 4 of the Pocket district, as given by Fisher; the Wilson of the Crab Orchard area; the coal recognized by Campbell on Poor fork as lying just under his "Gladeville Sandstone;" and that it is represented in the Tom's Creek field, Va., by the Lower Banner seam, and in the Elkhorn field, Ky., by the Lower Elkhorn.

Additional evidence of the approximate correctness of the identifications made is furnished by fossils associated with certain coal-horizons in the various fields.

It has been remarked by a competent palæobotanist that the base of the Wise formation (beds *A* to *C*) is perhaps equivalent to the Eagle coal-group of the Kanawha, W. Va., field, which group is believed to correlate with the Feds Creek seam of Kentucky, lying 230 ft. beneath the Lower Elkhorn and 400 ft., more or less, above the Lee Conglomerate. If this be even approximately true, bed *A* certainly lies no higher in the geologic column than the Lower Elkhorn, and could not be 1,200 ft. above the Lee, as shown in Campbell's section.

Again, David White, of the National Museum, says: [10]

> "The present state of knowledge does not justify a correlation of the Elkhorn with the coal beds in the Norton or Big Stone Gap region. It may, however, be remarked that the species of fossil plants from the Lower Elkhorn appear to bear a close relation to such material as I have been able to secure from the Banner group, at Dorchester, near Norton."

This agrees with the correlation suggested for the Russell Fork and Elkhorn fields.

But it must be admitted that the suggested correlations between Black Mountain coals and those of the Norton, Russell Fork, and Elkhorn fields are supported by few unquestioned facts. And though all available data have been used to throw

[10] *Bulletin No.* 348, *U. S. Geological Survey*, p. 32 (1908).

light on the subject, and the conclusions reached seem to be supported by a preponderance of evidence, there is need of much more detailed exploration of intermediate areas before the mutual relations of the important coal-horizons in the several fields can be positively determined.

In closing, it may be noted that, if the foregoing correlations are correct, the Pocahontas and New River coal-groups occur in the Lee Conglomerate, and are represented in this region by a few sporadic and worthless seams.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Electrolytic Oxygen in Cyanide Solutions.

BY T. H. ALDRICH, JR., BIRMINGHAM, ALA.

(San Francisco Meeting, October, 1911.)

THERE are two conditions generally prevailing upon the earth—those within atmospheric influence, tending towards oxidation, and those away from atmospheric influence, tending towards reduction. Practically all mineral substances from mines of any depth are in a reducing condition.

Since the cyanide process, in order to dissolve silver or gold, requires that the prevailing conditions under which it operates shall be oxidizing, and the materials usually acted upon being of a reducing character, it becomes necessary to supply oxygen to the solution carrying the cyanide. This oxygen is usually supplied through the medium of dissolved air in the solution, or through the medium of various chemical compounds, which upon combining with the solution or the ore give off a part of their oxygen.

Strange as it may seem, practically all mineral substances are partly soluble in water, especially water carrying alkali or cyanide. The greater the surface exposed and the finer the material is ground, the greater will be the rate of dissolving of the reducing agents from the ore into the cyanide solution. In most cases, if the solution carrying the ore particles is agitated with air, the air will dissolve into the solution faster than will the reducing-agents; but in some cases the reducing-agents will dissolve more rapidly on account of easy solubility or greater surface exposed. It is a dissolving race between the oxygen from the air and the reducing-agents from the ore, and if the reducing-agents predominate, cyanide will not dissolve the gold from the ore. In many cases it will dissolve some of the gold, because in a mass of irregular shape some of the gold particles might be exposed upon the outside surface of a particle of rock; but if the solution had to penetrate through cracks, the side-walls of which were lined with reducing-agent-

producing material, before the solution carrying oxygen could reach the gold it would have lost its oxidizing power. For this reason in many cases cyanide solutions will produce only a partial extraction of the gold or silver present.

It occurred to me that since water is composed of hydrogen and oxygen, if it be decomposed by the electric current, the hydrogen would bubble away and the oxygen would be carried by the solution. This was tried in December, 1908, upon an ore carrying amorphous iron sulphides from which all the gold could not be dissolved by cyanide with simple air-agitation, no matter what the cyanide strength or how great the time, although the gold as revealed by the microscope was all metallic. The process was tried first in an inverted bottle with the bottom cut out, the air being forced in through a glass tube in the cork to agitate the pulp. Two lead plates were inserted in the agitated pulp at the top. These plates were about 4 in. long and 0.5 in. wide, and $\frac{1}{16}$ in. thick. Through them was passed the current of an incandescent lamp, which being in series and burning dimly gave about 0.25 ampere ot current. The results were excellent from the beginning. The value of the ore was $4 per ton. It was ground in a tube-mill so that 60 per cent. passed a 200-mesh screen. The value of the tailings, after 48 hr. agitation with air alone, was $1.25; but after agitation for 2.5 hr. with air and electrodes inserted in the pulp as described above, the value was reduced to $0.40. This typical result was verified perhaps a thousand times, with uniformly good results.

In testing our solutions, a 2-lb. solution of cyanide is test 10. The alkali is tested on the basis of ten points over and above the alkali due to the cyanide, test 10 being a 2-lb. solution of caustic soda. The reducing-agents were tested with a 1 per cent. solution of potassium permanganate, 1 cc. of which in 10 cc. of the solution, after acidulating, equals test 10, it being much easier to keep track of these solutions by simple numbers than by keeping the records in pounds per ton.

Numerous tests were made in order to determine a proper electrode. Lead was found to be the best material. Many other substances, such as carbon, worked very well, but with the alternating current, there being no consumption of the lead electrode, lead proved most satisfactory.

The following tests upon the working-solution show the effect of the different electrodes. All the tests were made at the same time and with the same solution, using the direct current.

Lead electrode: Time, 4 min.; 0.25 ampere current.

	KCN.	Alkalinity.	Dbl.	Reducing-Agents.
Before, . .	8	+ 1	5	6
After, . . .	12	+ 2	0	4

Iron electrode: Time, 6 min.; 0.25 ampere current.

	KCN.	Alkalinity.	Dbl.	Reducing-Agents.
Before, . .	8	+ 1	5	6
After, . . .	7½	+ 6½	0	3

Iron electrode: Time, 12 min.; 0.25 ampere current.

KCN.	Alkalinity.	Dbl.	Reducing-Agents.
6	7½	0	2

(Showing destruction of the cyanide.)

Lead electrode: Time, 10 min.; 0.25 ampere current.

KCN.	Alkalinity.	Dbl.	Reducing-Agents.
12	3	0	3

There seems to be a regeneration of cyanide, and the process is certainly cheaper than any added oxidizer or even air-agitation of the solution.

We found by numerous experiments that the alternating current was as good as the direct current, and had the additional advantage of giving no deposit on the electrodes at lower current-density, and with lead there was no consumption of the electrodes even where the ore-pulp flowed over the electrodes. The way I explain this result is as follows:

Under the prevailing conditions certain electro-chemical actions take place by which the particles composing a molecule of a compound are resolved into the parts that the applied current-strength would resolve them into, and go into the solution on the one wave, and they do not re-combine on the returning current wave. In other words, dissociation takes place without being followed by re-combination. At any rate, no matter how the action is explained, it is carried on and works satisfactorily.

In electroplating, if the current is of low density the material deposited will be dense. If the current-density is increased,

the material deposited will be spongy. If the current-density is still further increased, the material which should be deposited will be disengaged by the action of the gases, and practically no deposit will result, the material going into the solution in a more or less spongy condition. We found that with a very high current-density no deposit of gold or silver accumulated upon the lead electrodes with direct current. Some of the electrodes after being in use six months were scraped, and the scrapings assayed, and showed only a trace of gold and silver.

Electrolyzed solution seems to be especially effective when used in connection with lead acetate or litharge added in the tube-mill during grinding. The electrolyzed solution going to the tanks shows no sulphocyanides, whereas, before the batteries were put in use, the solution showed a large amount.

As finally used in practice in January, 1909, a battery, supplied with alternating current, was placed in the barren sump. This battery consisted of 18 plates in series, each plate 6 by 6 in., with 110 volts between the two. The plates consumed 15 amperes, and produced sufficient oxidizing effect, or whatever other effect it may be, to keep the solution in condition to treat daily 40 tons of this ore. These plates, made of $\frac{1}{8}$-in. sheet lead, were built so as to form hollow rectangles in section, the rectangle being 6 in. high, 6 in. long, and 1.25 in. wide inside. The two ends were lapped at the top and holes punched. The plate was bolted to a paraffined plank 1 by 6 in. on the top side; 18 of these plates were connected in series. The distance between any two plates was $\frac{1}{8}$ in., and, of course, the current would travel principally across the $\frac{1}{8}$-in. gap, instead of around the $1\frac{3}{8}$-in. gap, from plate to plate. Lead wires were used from the surface of the solution down to the plates. We ground the ore in the tube-mill so that 60 per cent. would pass a 200-mesh sieve. Previous to using the batteries in the sump, the extraction in the tube-mill was 20 per cent. during grinding; after the batteries were used, the extraction in the tube-mill was 75 per cent. The effect of the batteries seemed to build up in the solution gradually and to lose from the solution gradually when the operation of the batteries was discontinued.

During two months in the fall of 1910 the mill was working coarse ground, partly-oxidized ore carrying considerable sul-

phides. The water at the hydro-electric plant was low, and the use of the batteries was discontinued because the mill was driven with steam, and no arrangement had been made to supply alternating current from any but the hydro-electric plant. During this time the tailings on $4 ore went up to $1.25 per ton, and immediately after the rains gave sufficient water to drive the hydro-electric plant, the values in the tailings diminished until $0.20 per ton was reached on identically the same ore with the same head-values; moreover, the reducing-agents dropped from 16 to 4. The time occupied in getting the working-solution up to this condition was two weeks. I consider that this process owes its value almost entirely to the presence of oxygen due to electrolysis, putting the solution ahead in the race for the reducing-agents and causing the gold and silver to dissolve in spite of the reducing-agents. However, it does not stop the reducing-agents from dissolving also, and although it produces solution of the gold in spite of the reducing-agents, it does not help precipitation, and if the reducing-agents are not decomposed by the batteries—and all of them are not—they build up in the solution rapidly to a point where zinc-shavings will not precipitate the gold.

Of course, in practice the cyanide solution contains reducing-agents of many kinds. The electrolytic action seems to reduce the influence of some, but not all of them. For example, I experimented on some highly-graphitic ore, and whether the normally-poor extraction was due entirely to the graphite or not, I do not know; but the solution, after electrolyzing, gave a very much better extraction than before electrolyzing. The action seems to decompose the sulphocyanides and the soluble sulphides, but not the alkaline sulphides and all of the many others always present.

A test on the electrolyzed solution 18 months after the batteries were installed showed:

Working-solution with alternating current, 0.25 ampere, and lead electrode.

	KCN.	Alkalinity.	Dbl.	Reducing-Agents.
Before, ...	8	1	0	15
After 10 min. electrolysis,	8	1	0	15

showing that the solution remained practically the same, or was electrolyzed as much as was necessary. However, testing

some of this same solution further by placing a piece of gold leaf upon its surface and allowing it to float, the gold leaf was dissolved in 71 min. on the working-solution and in 50 min. on the re-electrolyzed solution, showing that the additional electrolysis, although it had no apparent effect on the solution, gave an increased dissolving-rate. Grease in the ore or on the surface of the barren sump seemed to dissolve very rapidly in the treated solution and slowly in the untreated solution. We tarred our tanks inside and coated them with black oil outside, and more or less grease was frequently floating upon the surface of the solution where this effect was noticed.

Since the installation of this process it has treated successfully at this plant 25,000 tons of ore of all kinds, oxidized, partly oxidixed, and sulphides. Previous to the use of the batteries, in treating sulphide ores, the average cyanide-consumption was 1 lb. per ton, in some months running as high as 1.1 lb. After the use of the batteries the average was 0.45 lb., running for some months as low as 0.23 lb. per ton of ore treated.

We tried using batteries in the agitated pulp and in the solution, and found the result to be just as good if the plates were inserted in the barren sump as if inserted in the agitated pulp. The original lead plates placed in the barren sump are still there and in operation. They cost about $4 to insert originally and were inspected after 26 months of practically continuous service, and are to-day just as good as when they were first put in use.

I have applied for no patents on this process and do not expect to, and any one is free to use it. It should be a cyanide-saver, an accelerator, and a general solution-purifier.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Cyanide-Plant at the Treadwell Mines, Alaska.

BY W. P. LASS, TREADWELL, ALASKA.*

(San Francisco Meeting, October, 1911.)

THE purpose of this article is not only to describe the plant and method of cyaniding the Treadwell concentrates, but to present some of the results of the experimental work obtained in the past three years for the Alaska-Treadwell Gold Mining Co., at Douglas Island, Alaska, under the direction of F. W. Bradley, Consulting Engineer, and Robert A. Kinzie, General Superintendent, of the affiliated companies.

At the time the experimental work was undertaken the concentrates were being shipped to the smeltery at Tacoma, Wash., and the cost for treatment of 3-oz. (gold) concentrates was $11.95 per ton, divided as follows:

Smelting-charges,	$4.0
Loading, freight, insurance, etc.,	2.89
Interest due to time lost in transit and in settlement,	0.05
Loss due to settlement for 95 per cent. of the gold at $20 per ounce,	5.01
Total,	$11.95

From the experimental work described later, it was estimated that 96 per cent. extraction could be made by treatment on the ground, and that the cost, when treating 80 tons per day, would be $3.25 per ton, divided as follows:

	Per Day.	Per Ton.
Labor,	$66.16	$0.827
Chemicals,	76.60	0.960
Power and steam-heat,	67.60	0.845
Marketing-, refining- and other charges,	49.36	0.617
Totals,	$259.72	$3.250

Adding to this total the 4 per cent. treatment-loss, which on 3-oz. concentrates amounts to $2.48, gives a total cost of $5.73 per ton. Comparing this with $11.95, the cost when shipping to the smelter, leaves a net gain of $6.22 per ton by the local

* Cyanide Superintendent of the Alaska-Treadwell Gold Mining Co.

treatment. In addition to this saving, the cyanide-tailings would have an economic value due to the sulphur- and iron-content, as well as the value of the residual gold after oxidation.

I. Laboratory-Work.

1. *Character of the Concentrates.*—The concentrates, amounting to 1.8 per cent. of the original ore, contain: Fe, 40; S, 1; SiO_2, 11 per cent., and carry from 2.5 to 4 oz. of gold and 0.75 oz. of silver per ton. The gold- and silver-values amount to about 37 per cent. of the values contained in the original ore from the mine. The figures in Table I. are assays and averages of sizing-tests on concentrates from the various mills.

Table I.—*Assay Sizing-Tests of Treadwell Gold- and Silver-Ores.*

Size of Material.	Weight.	Assay-Value Per Ton.	Value.	Value in One Ton of Original.
	Per Cent.		Per Cent.	
On 20-mesh screen..........	0.44	$70.35	0.48	$0.31
Through 20, on 40.......	8.23	203.96	26.05	16.83
Through 40, on 60.......	10.96	143.89	24.39	15.76
Through 60, on 80.......	12.49	94.88	18.34	11.85
Through 80, on 100.......	10.38	60.85	9.78	6.32
Through 100, on 120.......	13.37	39.27	8.14	5.25
Through 120, on 150.......	7.69	26.61	3.17	2.05
Through 150................	36.46	17.10	9.65	6.23
	100.00		100.00	$64.60

(In this paper, all figures, unless otherwise stated, are based on the dry ton of 2,000 lb., with gold at $20.67 per oz. Silver-value is not included. Screen-mesh is expressed in openings per linear inch.)

On account of the decrepitation of the pyritic crystals during the process of drying, as well as the tendency of the particles to adhere to one another, all sizing-tests were made in water without previous drying of the sample. Results show that the values vary directly with the degree of comminution. It being understood that the concentrates are derived from pulp after amalgamation at the mills, it seemed evident that the gold was present as metallics incased within the pyrite. Work done in the laboratory previous to the year 1909 confirmed this view, and indicated that a satisfactory extraction could be obtained by regrinding, followed by amalgamation and cyanidation.

2. *Preliminary Tests.*—For the preliminary tests ordinary quart-size glass jars were used, and agitated by placing them on the distributing-boxes of the Frue vanners. In each case an excess of lime and a small amount of lead acetate were added to the solution. Sizing and assaying of the residues showed the gold to have been removed from the finely-ground particles, while the large percentage ot value remained in the coarse particles.

The next step was with 50-lb. composite samples from all the mills. A clean-up barrel was fitted with iron balls and used to grind the concentrates to a 200-mesh product, which was passed over a 2- by 4-ft. amalgamated copper plate, the pulp collected and cyanided in small agitation-vats, built on the plan of "Brown" or "Pachuca" tanks. These were 14 in. in diameter and 4 ft. high, with a 1.25-in. pipe suspended through the center. At the apex of the cone a needle-valve regulated the supply of air.

The 50-lb. samples were treated in these small tanks, the results given in Table II. being a fair average from one of these tests.

TABLE II.—*Results Obtained from Treatment of 50-Lb. Composite Samples from Treadwell Mills.*

Assay-value of original concentrates, ...	$77.40
Amalgamation-extraction based upon head- and tail-assays, per cent., ...	74.16
Proportion of ground product passing 200-mesh screen, per cent.,	98.00
Assay-value of cyanide heads, ...	$20.00
Assay-value of cyanide tails, ...	$2.40
Cyanide-extraction based upon head- and tail-assays, per cent., .	88.00
Cyanide-extraction based upon solution-assays, per cent., . .	90.00
Total extraction by amalgamation and cyanide, per cent., . .	96.89
Time of cyanide-treatment, hours, ...	12
Strength of cyanide solution (1 lb. per ton), per cent., . .	0.05
Cyanide-consumption per ton of concentrates, pounds, . .	2.6
Lime-consumption per ton of concentrates, pounds, . . .	14.0

The tests in Table II. show that 75 per cent. of the gold could be obtained by fine grinding and amalgamating, or 96 per cent. by fine grinding and amalgamating followed by cyaniding.

II. Experimental Plant.

Having proved that a satisfactory extraction could be obtained, the next step was to determine the most economical method of handling the material. For this purpose, an addition was built to one of the mills, in which was installed an Abbé 4- by 12-ft. tube-mill, with the necessary plates for amalgamation. The tube-mill ground 0.5 ton of concentrates per hour to pass a 200-mesh screen, or 1 ton per hour, 95 per cent. of which would pass a 200-mesh screen. With a cleaner separation of the coarse return-product, the grinding-capacity could have been increased. Various forms of classifiers were tried, the Dorr "drag" classifier proving the most satisfactory, not only making a good separation between the sands and fines, but acting as a feeder to the tube-mills. In later practice, with a duplex Dorr classifier treating 125 tons daily of concentrates discharged from a larger tube-mill, the following results were obtained:

	Screen Mesh,		
	On 100. Per Cent.	On 200. Per Cent.	Through 200. Per Cent.
Feed to classifier, . . .	10.1	26.4	63.5
Coarse discharge, . . .	51.3	44.0	4.7
Fine overflow, ...	1.1	29.7	69.2

As ordinarily used, the water is much in excess of the ore, so that the fines are carried over by the rising current from the rakes; but in operating the Dorr to its fullest capacity on concentrates, it is necessary to reduce the volume of water used, and depend upon the greater specific gravity of the pulp holding the fines in suspension until carried over with the fine product.

Callow cones arranged with suspended diaphragms were used for de-watering the sands previous to cyaniding. When delivering a clear overflow, one standard 8-ft. cone was found to have an hourly capacity of 1 ton of concentrates with 15 tons of lime-water, making a spigot-product of less than 35 per cent. of moisture.

Grinding in an alkali solution equivalent to 2 lb. of lime per ton kept the amalgamation-plates in a clean, bright condition, and materially aided in the settlement of slimes. Without lime the pulp discharged from the tube-mill possessed a latent acidity equivalent to 6 lb. of lime per ton of concentrates,

which made plate-amalgamation almost impossible on account of a black surface-deposit completely coating the plates within 10 min. after being dressed.

Sea-water as a substitute for lime-water was tried, and although it gave better amalgamation-results than fresh water, it was not as satisfactory as the lime solution. The plates became coated with slime and the solution remained turbid in the tanks.

By fine grinding and amalgamating in 15-ton lots, an extraction of from 75 to 80 per cent. was obtained, the extraction varying directly with the fineness of grinding. On the original ore this amounts to an extraction of 84 per cent. by amalgamation.

To obtain the best results by amalgamation, mercury was fed into the tube-mill with the concentrates. After having completed the amalgamation-tests, during which time 7,050 oz. of amalgam were recovered, the mill was emptied of its pebbles and the inside thoroughly cleaned, in order to determine the amount of mercury or amalgam that remained. No free mercury and only 3 per cent. of the total amalgam was recovered from the tube.

Upon again feeding the concentrates to the tube-mill without either cyanide or mercury, a concentration took place inside the mill, as shown by the daily sampling of the feed and discharge of the mill, Table III.

TABLE III.—*Results Obtained by Treatment of Concentrates in the Tube-Mill.*

	Original Feed from Bins.	Tube-Feed (Includes Coarse Return Product).	Pulp as Discharged from Tube-Mill.	Slime Finer than 200-Mesh.
First 6 hr. grinding........	$48.00	$95.00	$88.00	$18.00
Second 6 hr. grinding......	48.00	113.00	103.00	16.90
Third 6 hr. grinding.........	48.00	131.00	120.00	19.20

Cyanide was then introduced into the grinding-solution and samples assayed as follows:

	Strength of Cyanide in Grinding-Solution.	Original Feed from Bins.	Tube-Feed (Includes Coarse Return Product).	Pulp as Discharged from Tube-Mill.	Slime Finer than 200-Mesh.
	Per Cent.				
First 6 hr. grinding........	0.05	$48.00	$96.00	$80.00	$14.60
Second 6 hr. grinding.....	0.05	48.00	67.00	62.00	11.60
Third 6 hr. grinding.......	0.046	48.00	68.40	59.20	12.00

The method of grinding proving successful, the next step was to test the cyanide process on a larger scale. For this purpose a Brown or Pachuca agitation-tank, 10 ft. in diameter and 22 ft. high, with 60° conical bottom, was erected beside the tube-mill, together with four small redwood tanks. A Merrill precipitation-press was later purchased and a few filter-leaves placed on the suction of the gold-pump for clarifying the solutions. This completed the necessary equipment for cyaniding the tube-mill product in 15-ton lots. The gold-values were removed from the pulp by successive washes and decantations.

TABLE IV.—*Results of Zinc-Dust Precipitation, Obtained in Experimental Plant.*

Cyanide Per Ton of Solution.	Lime Per Ton of Solution.	Gold Before Precipitation.	Gold After Precipitation.	Gold Precipitated.
Pounds.	Pounds.			Per Cent.
0.44	0.42	$13.60	$12.40	8.82
0.80	0.46	13.00	13.00	0.00
0.92	0.95	6.60	2.20	66.67
1.53	1.07	1.20	0.05	98.81
0.40	1.30	12.10	2.50	79.26
0.40	1.30	4.50	1.60	65.25
1.24	1.35	17.00	0.10	99.41
1.76	1.35	14.60	0 05	99.66
0.80	1.41	3.40	0.20	93.23
1.93	1.47	7.60	0.05	99.34
1.00	1.85	12.80	0.05	99.61
0.98	1.91	5.20	2.80	46.15
2.44	2.18	4.80	0.10	97.92
2.76	2.35	12 60	0.05	99.53

The figures of zinc-dust precipitation presented in Table IV. show the non-precipitation of the values when the lime-content of the solutions fell much below 1 lb. per ton. With solutions high in lime an excess of cyanide was added to keep the filter-cloths clear. In each case an excess of zinc-dust was added.

The flow-sheet, Fig. 1, shows diagrammatically the method used for these experiments, with the exception that the filter-box shown was later superseded by a Kelly filter-press (type 1 B) of 50 tons daily capacity, which did away with the numerous washes and decantations previously required.

The cycle of operations of the Kelly press and the time of working, when forming a 1-in. cake of about 4 tons of concentrates (dry weight), are as follows:

Operation of the Kelly Press.

	Time. Minutes.
Filling press,	3
Forming cake,	2
Returning excess pulp,	2
Washing,	12
Returning excess wash,	2
Drying,	8
Opening, discharging, and closing,	15
Total time of one cycle,	44
Moisture in pulp fed to press, per cent.,	35
Moisture in tailings cake discharged, per cent.,	8 to 10
Pressure of forming cake,	30 lb. per sq. in.
Amount of wash-water used per ton of concentrates,	0.5 ton.

The first 25 test-runs made in the experimental plant are summarized in Table V.

TABLE V.—*Results of First Twenty-Five Experimental Test-Runs on 700-Foot Mill-Concentrates.*

No. of Test.	Tons Treated.	[a] Assay Per Ton. Original Concentrates.	[a] Assay Per Ton. Ground Product.	Treatment During Grinding.	Extracted During Grinding.	Ground Product Through 200-Mesh.	Ratio Ore to Solution.	[a] Assay Per Ton. Agitation-Heads.	[a] Assay Per Ton. Cyanide-Tails.	Extracted by Cyanide in Pachuca.	Cyanide Solution Used.	Lead Acetate Per Ton Concentrates.	Time of Agitation.	Cyanide-Loss Per Ton Concentrates.	Changes of Solution.	Total Extraction.
					Per Cent.	Per Cent.				Per Cent.	Per Cent.	Pounds.	Hours.	Pounds.	No.	Per Cent.
1	20	$42.16	$19.63	Amalgamation...........	54.0	94.0	1 to 1.6	$19.63	$4.00	79.0	0.35	....	48	6.70	2	90.0
2	15	54.80	9.00	Amalgamation...........	83.0	99.8	1 to 2.2	9.00	.95	89.0	0.15	1.5	18	4.00	3	98.3
3	18	42.00	10.40	Amalgamation...........	75.2	99.6	1 to 2	10.40	1.40	86.4	0.125	1.14	16	2.97	3	96.6
4	16	47.20	10.00	Amalgamation...........	78.8	99.8	1 to 2	10.00	1.20	88.0	0.1	1.0	16	1.92	3	97.8
5	10	32.00	8.40	Amalgamation...........	73.7	97.0	1 to 3	8.40	.80	90.4	0.14	1.0	24	2.00	2	97.5
6	10	56.80	9.60	Amalgamation...........	83.1	97.0	1 to 3	9.60	1.80	81.2	0.07	....	10	2.30	3	96.8
8	8	50.00	8.80	Amalgamation...........	82.4	98.0	1 to 3	8.80	2.30	73.8	0.038	1.0	18	1.44	2	95.4
9	9	30.80	9.00	Amalgamation...........	70.7	97.0	1 to 2	9.00	1.60	71.7	0.1	....	12	1.08	2	94.8
10	15	52.00	14.60	Amalgamation...........	71.9	90.0	1 to 2.1	14.60	2.00	87.6	0.15	1.0	24	0.90	2	96.1
11	15	37.20	13.40	Amalgamation 0.002 per cent. cyanide.	64.0	88.0	1 to 2	13.40	2.40	82.0	0.15	1.0	24	0.96	2	93.6
12	15	40.80	9.60	Amalgamation 0.05 per cent. cyanide.	76.5	98.0	1 to 2	9.60	2.40	75.0	0.15	....	24	4.46	2	94.0
13	15	46.00	9.40	Amalgamation 0.025 per cent. cyanide.	79.6	100.0	1 to 2	9.40	1.70	82.0	0.15	0.67	24	2.20	2	96.3
14	15	36.80	9.80	Amalgamation 0.05 per cent. cyanide..	73.4	100.0	1 to 2	9.80	1.60	83.6	0.15	....	24	3.50	2	95.0
15	15	36.00	5.00	0.07 per cent. cyanide..	86.1	100.0	1 to 2	5.00	1.12	77.6	0.15	1.0	24	4.40	2	96.9
16	7	48.00	18.00	Concentration...........	62.4	100.0	1 to 4	18.00	.90	95.0	0.15	....	18	1.60	2	98.5
17	7	48.00	16.90	Concentration...........	64.7	100.0	1 to 4	16.90	1.10	93.5	0.15	....	18	1.36	3	97.6
18	9	48.00	19.20	Concentration...........	60.0	99.0	1 to 3	19.20	1.80	90.6	0.075	....	18	2.28	3	96.2
19	12	48.00	13.20	0.05 per cent. cyanide..	72.4	99.0	1 to 2	13.20	2.60	80.3	0.1	....	12	5.10	2	94.6
20	10	48.00	12.00	0.046 per cent. cyanide	75.0	99.0	1 to 2.2	12.00	2.60	78.3	0.033	....	18	4.80	3	94.5
21	10	32.00	14.00	0.018 per cent. cyanide	56.2	99.0	1 to 2.3	14.00	2.80	80.0	0.036	....	36	3.70	4	91.2
22	18	28.00	22.40	0.024 per cent. cyanide	20.0	97.0	1 to 2	22.40	2.40	89.2	0.025	....	24	2.90	3	91.4
23	16	33.00	12.20	0.032 per cent. cyanide	63.0	99.0	1 to 2	12.20	.90	92.6	0.125	....	24	4.70	3	97.2
24	16	55.00	15.35	0.028 per cent. cyanide	72.1	99.0	1 to 2	15.85	1.60	89.5	0.12	....	16	5.20	3	97.8
25	15	46.00	17.60	0.042 per cent. cyanide	61.8	99.0	1 to 2	17.60	2.08	88.2	0.12	....	16	5.00	2	95.4
26	15	55.00	8.00	0.066 per cent. cyanide	85.4	99.0	1 to 2	8.00	2.90	63.7	0.12	....	16	4.30	2	94.8

[a] All values are in gold at $20 per ounce. Tests 2, 6, 8, 9, 10, 16 and 17 given preliminary alkali agitation. All solutions contained an excess of lime.

The actual net value of the bullion recovered by amalgamation was 3.7 per cent. in excess of the theoretical extraction figured from head- and tail-assays. The actual value of the precipitate recovered was 5 per cent. in excess of the theoretical extraction.

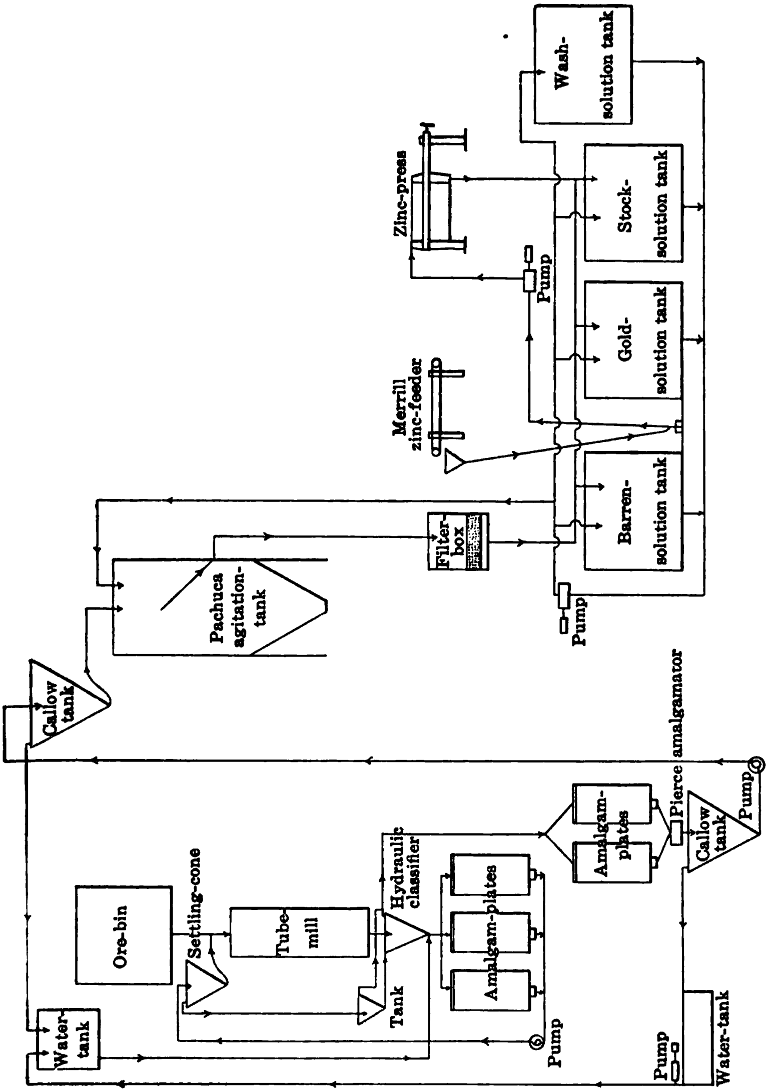


FIG. 1—FLOW-SHEET OF EXPERIMENTAL CYANIDE-PLANT.

The results of the tests showed that 75 per cent. of the gold could be recovered by grinding and amalgamating, or 96 per cent. by the combined method of amalgamating and cyaniding.

Results also showed that during the process of grinding in 1.5-lb. (0.075 per cent.) cyanide solution, a similar extraction could be obtained without amalgamation. Thus a satisfactory extraction was obtained either by amalgamating and cyaniding or by cyaniding direct.

A preliminary agitation with an alkali solution was found to shorten the time of cyanide treatment and save 25 per cent. in the cyanide-consumption.

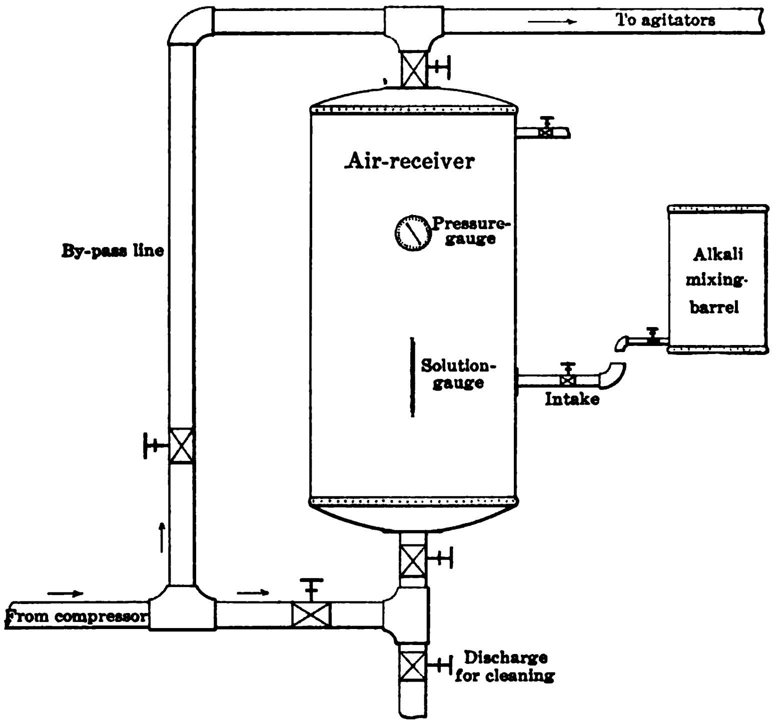


FIG. 2.—METHOD OF PURIFYING AIR.

Passing the air used for agitation through a receiver filled with a solution of caustic soda or milk of lime also decreased the cyanide-consumption, presumably by the removal of oil and carbonic oxides from the air. The pipe-connections illustrating the method of adding the alkali solution are shown in Fig. 2.

When grinding in cyanide solution stronger than 1 lb. per ton (0.05 per cent.), followed by amalgamation, it was difficult

to keep the plates bright, due to a dull white surface-deposit, which if allowed to remain turned to a dull gray. A Muntz-metal plate was substituted for a copper plate, but as all the plates were silver coated no variation in the result was noted.

The results obtained from this extended period of investigation, lasting over two years and at a cost of $27,794, justified the building of a plant of 100 tons daily capacity. This cost was largely offset by the ability of the final plant to treat the concentrates without the usual alterations necessary in starting a new mill. It also formed the nucleus of the final mill-crew.

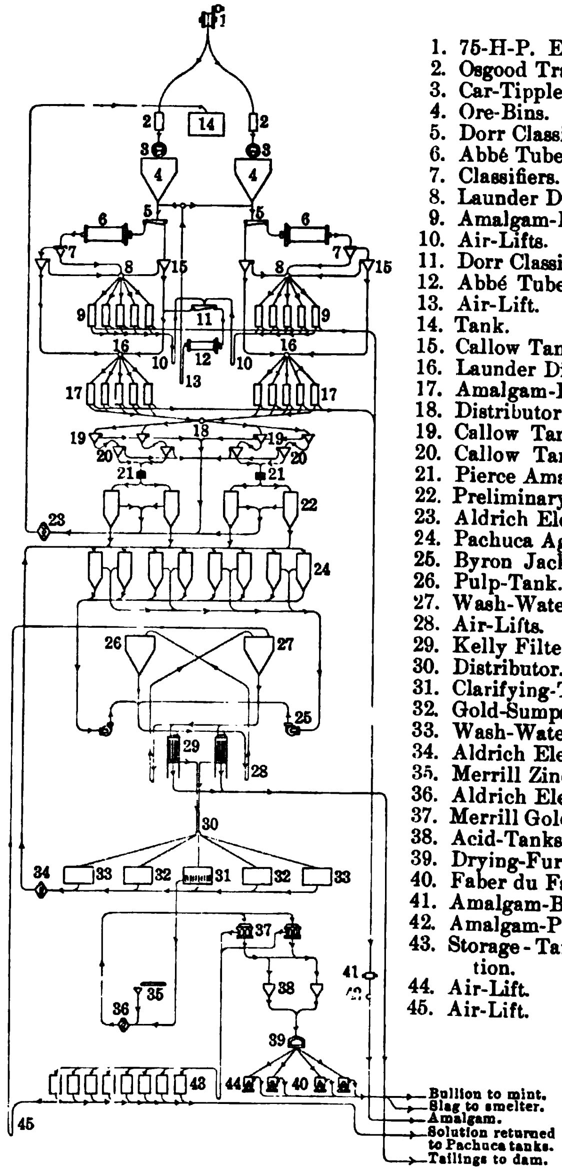
As the abandonment of amalgamation of high free-gold values in favor of direct cyaniding seemed a somewhat radical change, the new mill was planned for operating either way, and ultimately nearly 5,000 tons were treated by each method before deciding to cast out the time-honored amalgam-plate. All of the equipment purchased for the experimental work was used in the permanent plant, which was completed in September, 1910.

III. The 100-Ton Cyanide-Plant.

The cyanide-plant consists of three main buildings located on a hill-side 200 ft. above the stamp-mills. The upper building contains the grinding-and-amalgamating plant, with a lower floor for solution-storage tanks. The lower contains the cyanide equipment proper, while the refinery is in a concrete building at one side, as shown in Fig. 3.

The five mills on the island contain a total of 900 stamps, and crush approximately 5,000 tons daily. The crushed ore after amalgamation is concentrated on 360 Frue vanners, yielding an average of 90 tons of concentrates daily, of from 2.5 to 4 oz. of gold per ton. A flow-sheet of the operations is shown in Fig. 4.

From the vanner-boxes the concentrates are shoveled into specially-constructed flat-bottomed steel cars. These cars, each holding 2 tons of concentrates, are made up into trains at the mills, and brought by locomotives to the foot of the incline below the cyanide-plant. This incline is 900 ft. long with 14° rise. A Union Iron Works geared hoist, driven by a 75-h-p. electric motor, brings the train to a switch above the upper building. Beginning with this switch, the entire plant is in duplicate throughout.



1. 75-H-P. Electric Hoist.
2. Osgood Track-Scales.
3. Car-Tipples.
4. Ore-Bins.
5. Dorr Classifiers.
6. Abbé Tube-Mills.
7. Classifiers.
8. Launder Distributors.
9. Amalgam-Plates for coarse pulp.
10. Air-Lifts.
11. Dorr Classifier.
12. Abbé Tube-Mill.
13. Air-Lift.
14. Tank.
15. Callow Tanks.
16. Launder Distributors.
17. Amalgam-Plates for fine pulp.
18. Distributor.
19. Callow Tanks.
20. Callow Tanks.
21. Pierce Amalgamators.
22. Preliminary Agitation-Tanks.
23. Aldrich Electric Triplex Pump.
24. Pachuca Agitation-Tanks.
25. Byron Jackson 4-in. Cent. Pumps.
26. Pulp-Tank.
27. Wash-Water Tank.
28. Air-Lifts.
29. Kelly Filter-Presses.
30. Distributor.
31. Clarifying-Tank.
32. Gold-Sumps.
33. Wash-Water Sumps.
34. Aldrich Electric Triplex Pump.
35. Merrill Zinc-Feeder.
36. Aldrich Electric Triplex Pump.
37. Merrill Gold-Precipitation Presses.
38. Acid-Tanks.
39. Drying-Furnace for Precipitate.
40. Faber du Faur Furnaces.
41. Amalgam-Barrel.
42. Amalgam-Press.
43. Storage-Tanks for barren solution.
44. Air-Lift.
45. Air-Lift.

Fig. 4.—Flow-Sheet of 100-Ton Cyanide-Plant.

Leaving the switch by gravity, the cars are weighed, sampled, and run into revolving tipples. Upon releasing the brake the tipple revolves, turning the car bottom up and dropping the load from the car. The change in the center of gravity then causes the tipple to right itself, and the empty car is weighed and returned to the main switch.

Most of the water is removed from the concentrates while in the vanner-boxes by the aid of a bumper, which is simply a large air-piston machine mounted on a truck and moved from box to box. This bumping causes the concentrates to readjust themselves and pack in the bottom of the box, while the water is run off, leaving about 12 per cent. of moisture in the concentrates. It is considerably easier to shovel the concentrates into the cars after the bumping.

The concentrates are sampled while in the car by means of a long ship-auger. With the ordinary long spoon it was impossible to obtain satisfactory checks in the samples, as the concentrates are usually covered with water. Unslaked lime is added to each of the empty cars as it leaves the tipple in order to reach the concentrates at the earliest possible stage. It also forms a line of cleavage, causing the concentrates to dump clean from the bottom.

From the cars the concentrates fall into 100-ton steel storage-bins, 15 ft. in diameter, with 55° conical bottoms. The concentrates in the bins are kept covered with water, which effectually prevents oxidation of the "sulphurets" while lying in the bins. From this point until the cyanide treatment begins the concentrate is in strong lime solution at all times.

At the apex of the conical bottom of each bin tight-fitting gates control the outflow of concentrates, which is at once sluiced directly into Dorr classifiers, Fig. 5. The sluicing medium is the coarse return-product referred to later. There are three Dorr classifiers driven by one 7.5-h-p. electric motor, one feeding into each tube-mill and making 24 strokes per minute. This rate of speed, causing greater agitation, was found necessary to separate the large bulk of the fine from the coarse.

The coarse product of the classifiers falls into the spiral feeders of the tube-mills. These mills are of the Abbé type, 5 by 22 ft., lap-welded, trunnion bearings, with corrugated sec-

tional liners; 3-in. Danish flint pebbles are used for the grinding.

Two 75-h-p. motors on three-phase circuit at 2,200 volts are belted to an overhead central line-shaft, which in turn is belted to the pinion-shaft of the tube-mills. The tubes are driven from the discharge ends and make 27 rev. per min. The mills are controlled by friction-clutch pulleys on the central line-shaft.

For the period from May 15 to July 15, 1911, one tube-mill ground at the rate of 88.75 tons of concentrates per 24 hr. actual running-time, the power-consumption averaging 64 h-p. By replacing each 75-h-p. motor with a 100-h-p. motor, and substituting leather for canvas belts on the main drive, the power-consumption was reduced to an average of 59 h-p. for the same tube duty. This was with the tube just half filled with pebbles, the normal running-load. By increasing the pebble-load to 6 in. above the center of the tube, the power-consumption rises to 75 h-p., and both the quantity of tube-feed and the fineness of the product discharged are increased.

The following is an average screen-analysis of the feed and discharge of one 5- by 22-ft. mill, when grinding an original feed of 88.75 tons per 24 hours:

	On 100-Mesh. Per Cent.	On 200-Mesh. Per Cent.	Through 200-Mesh. Per Cent.
Feed,	48.7	41.5	9.8
Discharge,	10.1	26.4	63.5

The pulp contained 38.5 per cent. of moisture.

When the concentrates are amalgamated previous to cyaniding, the product discharged from the tubes is distributed over 10 copper amalgamating-plates, each 4 ft. 8 in. wide by 10 ft. long, plated with 2 oz. of silver per square foot.

The pulp flows from the plates into launders built into the floor. No traps are used, as they are quickly clogged by the metallic iron which accumulates in the concentrates from the wear of the various machines used in the processes of mining and milling.

This iron, if allowed to accumulate in the coarse return-product, will amount to as much as 15 per cent. of the total. Experiments are now being carried on with a magnetic device for removing the iron from the pulp.

From a sump in the launder an air-lift elevates the pulp to a *spitzlutte*, from which the coarse material is continuously drawn into a Dorr classifier, the coarse from which feeds a 4- by 12-ft. Abbé tube-mill, similar to the larger ones described above. The discharge from this mill joins the overflow from the *spitzlutte*, and is elevated by air-lifts to two settling-cones, so situated that the spigot-discharge from them becomes the sluicing medium for the original feed referred to above.

Two points will be observed here: (1) that the Dorr classifiers are at present doing all the classifying for the mill; and (2) that the concentrates are carried around in a closed circuit from which there is no escape until the particles have become fine enough to join the overflow from the back of the Dorr classifiers.

The Dorr overflow, which is the product cyanided, is more than 98 per cent. through 200-mesh. The remaining 2 per cent. is silica from the wear of the pebbles. Of the concentrates, the entire product will pass a 200-mesh screen.

The overflow of the Dorrs passes into two Callow de-watering-cones, the spigot-product of which is distributed over 10 amalgamating-plates similar to the coarse amalgamating-plates previously described. From the plates the pulp flows into launders, thence into a 6-in. pipe, 37 ft. long, having a fall of 0.75 in. per foot, which conveys the pulp directly to the lower or cyanide building.

In the lower building the pulp is received into a wooden distributing-box, from which it flows through two Pierce amalgamators into four 8-ft. Callow cones. The spigot-product from these cones discharges into four similar ones placed lower than the first set.

The spigot-product from the lower cones enters one of four Pachuca tanks, where it receives a preliminary treatment of 3 hr. agitation in a solution containing 2 lb. of lime per ton (0.1 per cent.), after which it is allowed to settle and the clear solution is decanted. The filling, agitating, settling, decanting, and discharging of a 25-ton charge of concentrates, which includes 46 tons of lime solution, requires somewhat less than 24 hr. This preliminary treatment saves in the subsequent treatment at least 1 lb. of cyanide per ton of concentrates.

The overflow lime-water from the Callow cones enters the

same sump with the decanted lime-water from the preliminary treatment, and is pumped by an Aldrich triplex 7- by 9-in. electric pump into a reservoir of 75 tons capacity situated in the upper building. The thickened pulp, ranging from 1.8 to 2.2 specific gravity, is drawn into one of eight Pachuca tanks, where it is given the cyanide treatment.

All Pachuca tanks in the mill are 10 ft. in diameter and 30 ft. high, with 60° conical bottoms, Fig. 6. When filled to the level found best for agitating (which is 6 in. below the top of the central column), each tank holds a volume equivalent to 51 tons of water. This is equal to the regular charge of 30 tons of concentrates with 40 tons of solution, although as high as 40 tons of concentrates have been treated as one charge without any difference in extraction-results.

The floors under the Pachucas, as well as all other floors in the building, are of smooth concrete sloping to a central sump, supplied with small pumps to return any escaped solution or pump to the proper tanks.

The first cyanide treatment consists of 8 hr. agitation in a 2-lb. (0.1 per cent.) cyanide solution; either potassium or the mixed cyanides being successfully used. Alkali is kept at 1.25 lb. (0.063 per cent.) of lime (CaO) per ton of solution. Lime is added during the treatment if the titrations show below that figure; 18 hr. is allowed for settlement and decantation of this solution.

Decantation takes place through a flexible hose, which is made as follows: Canvas coated with tar is wrapped around pieces of old boiler-tubing 3 in. in diameter and 4 in. long, spaced 0.75 in. apart. The canvas between the short lengths of tubing is wrapped with wire, making the diameter of these spaces slightly smaller than that of the tubing, thus insuring flexibility as well as avoiding the shifting of the tubing. Attached horizontally to the top of the flexible hose is a 3-in. slotted pipe. In operation this slotted intake floats by the aid of two adjustable air-cylinders. The arrangement of these cylinders is such as to allow of the vertical adjustment of the intake-pipe to any depth of submergence desired.

The long settlement allowed, with the excessively fine condition of the concentrates, their high specific gravity, from 4.6 to 5.0, and the high alkalinity of the solution, leaves a 30-ton

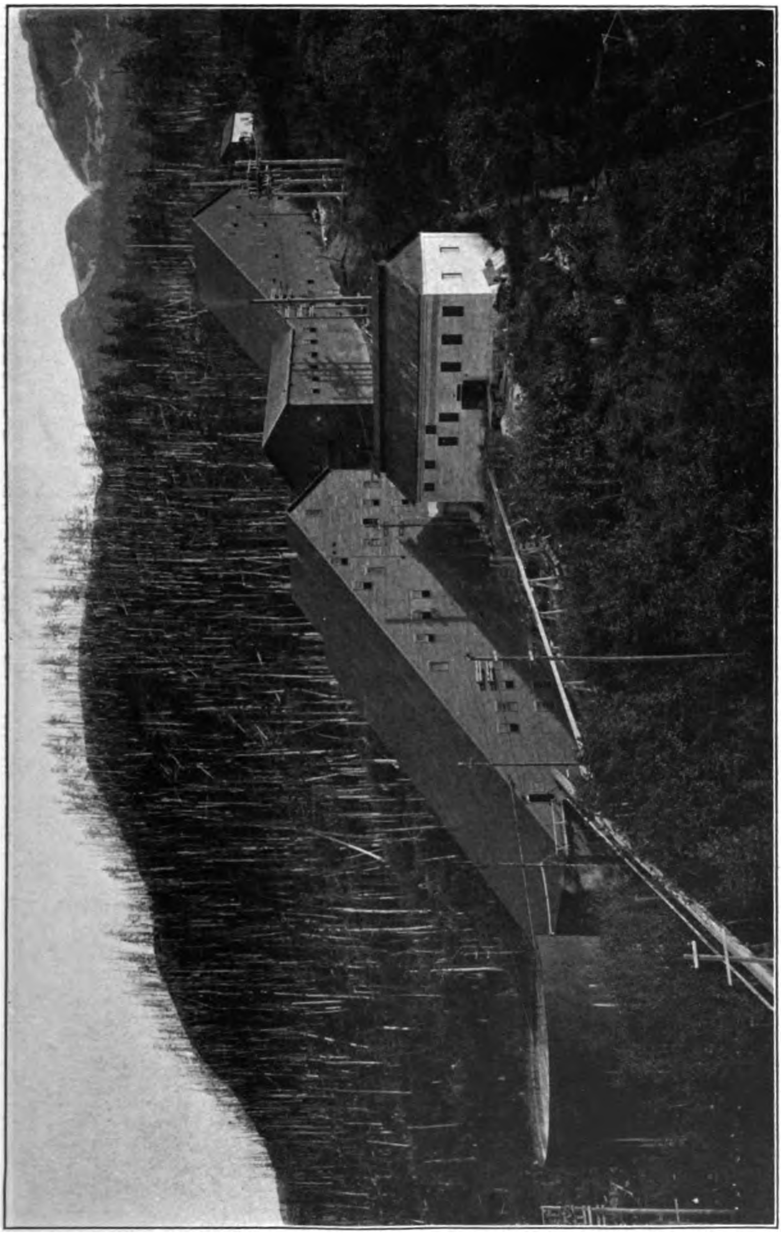


FIG. 3.—CYANIDE-PLANT OF ALASKA-TREADWELL GOLD MINING CO.

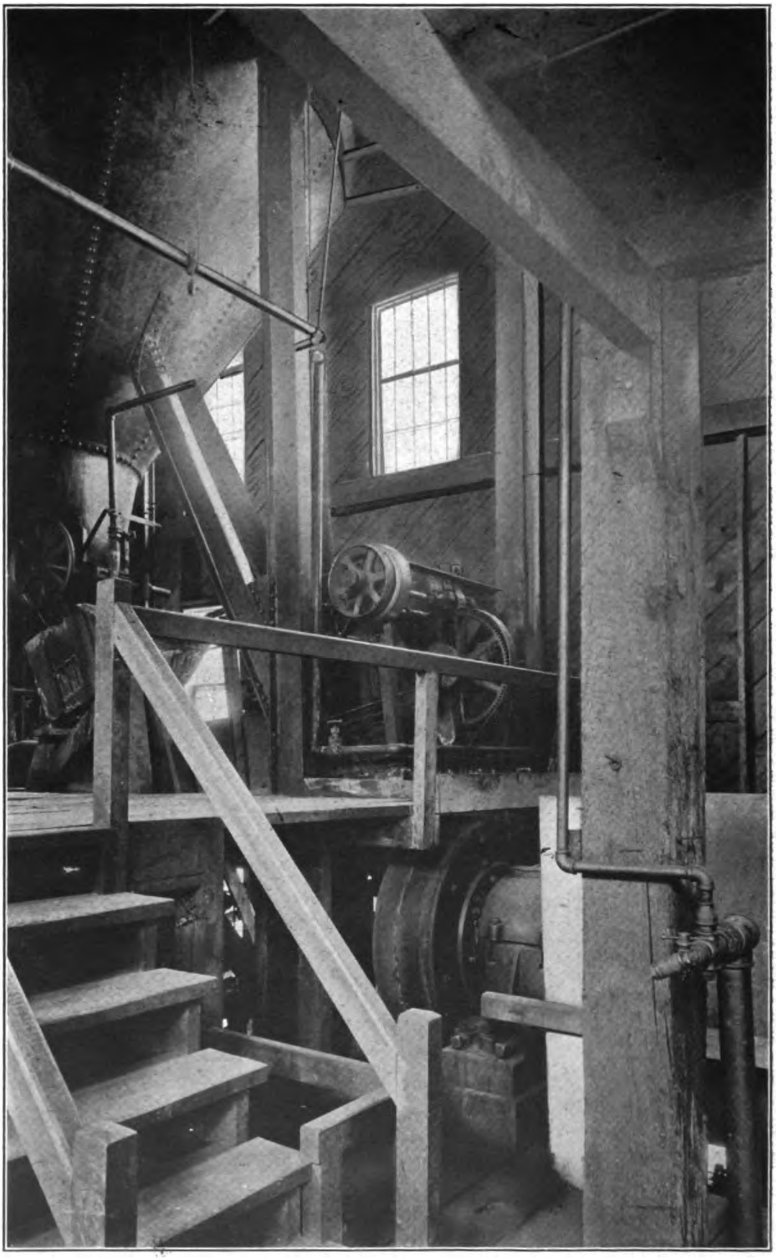


FIG. 5.—CONICAL CONCENTRATES-BIN EMPTYING INTO DORR CLASSIFIER, WHICH IN TURN FEEDS INTO SPIRAL OF TUBE-MILL.

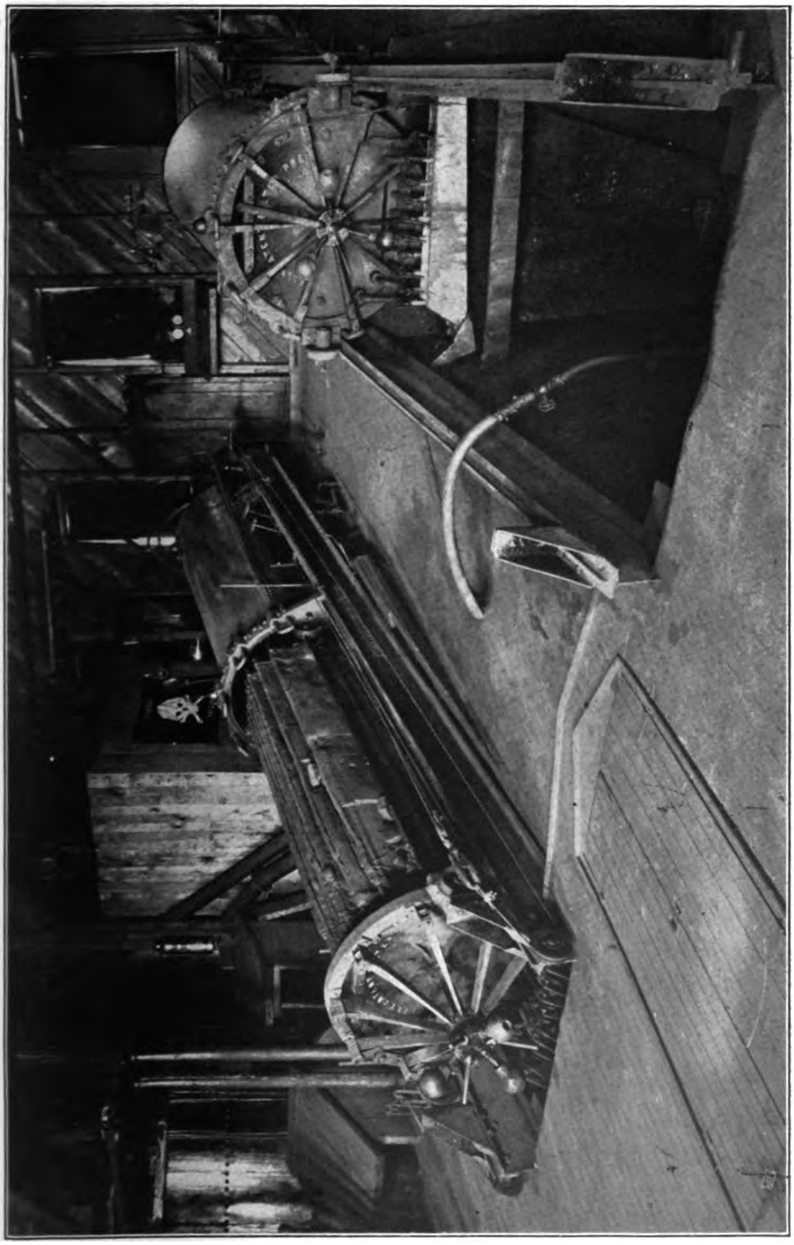


Fig. 7.—Kelly Filter-Presses.

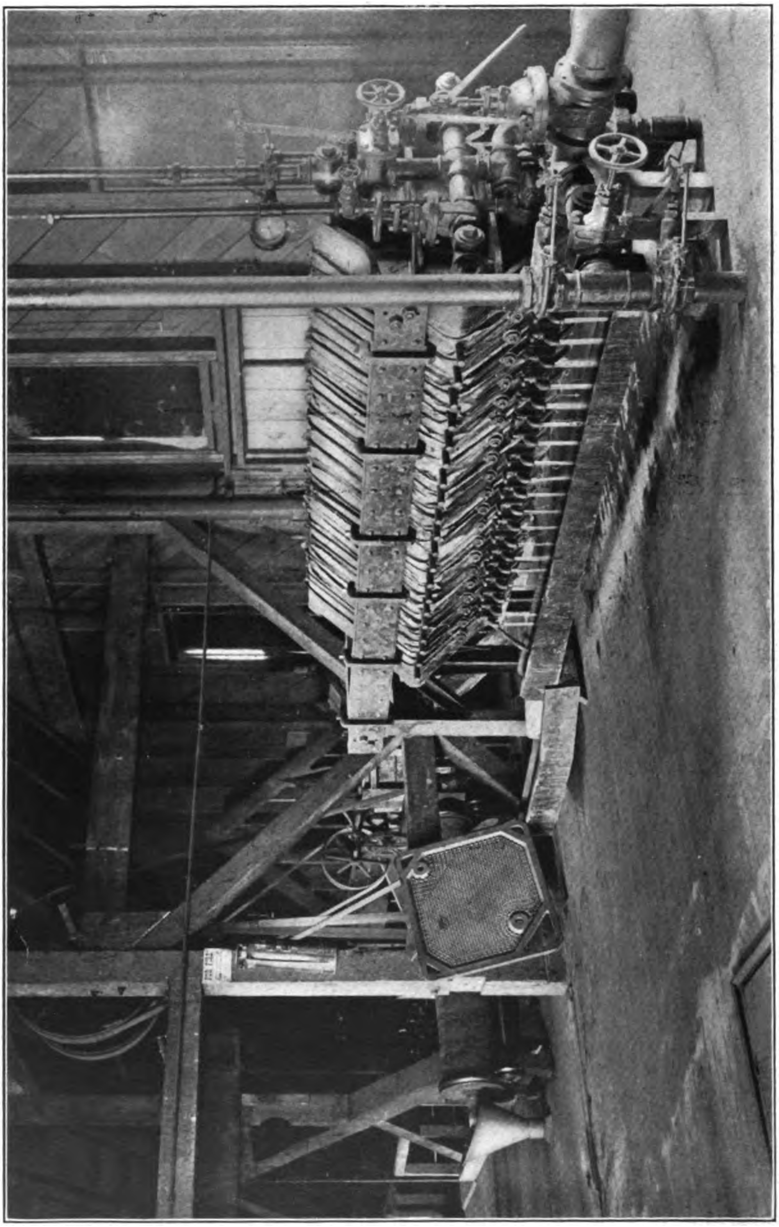


Fig. 8.—Treadwell Sluicing Clarifying Filter in Operation.

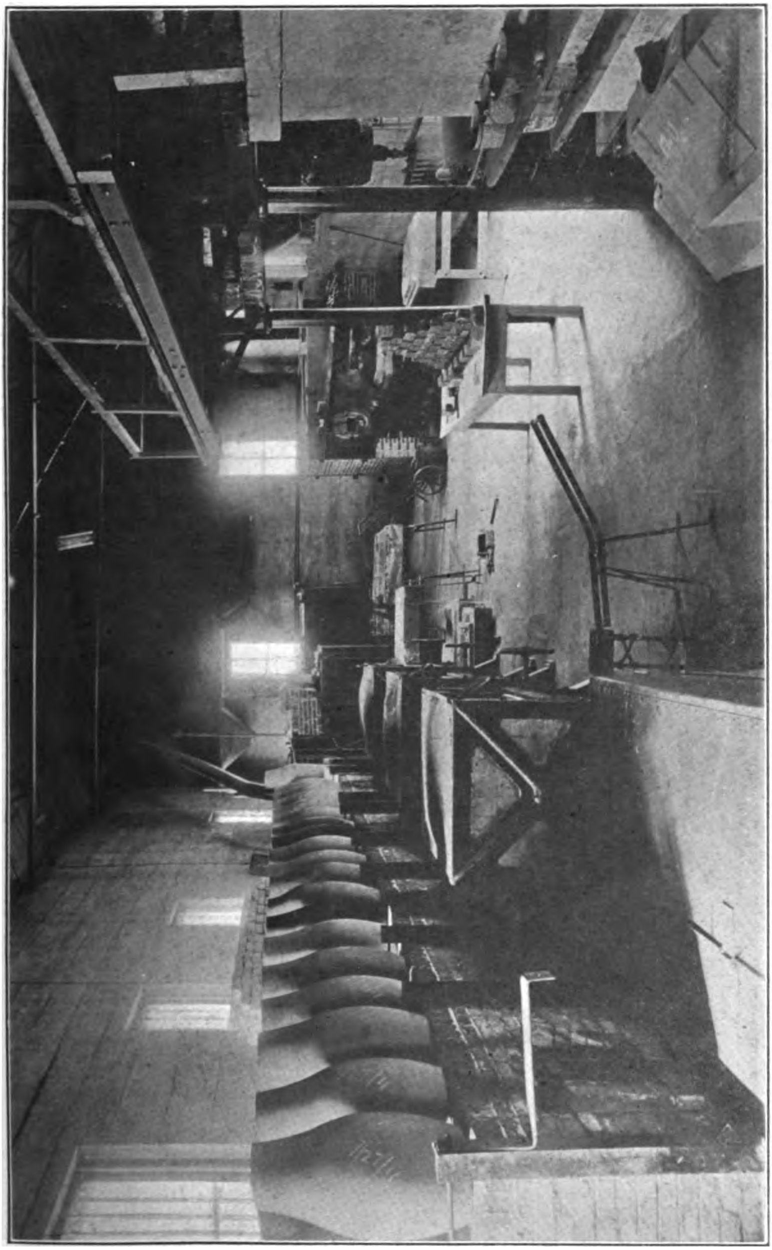


FIG. 9.—REFINERY-ROOM OF ALASKA-TREADWELL GOLD MINING CO.

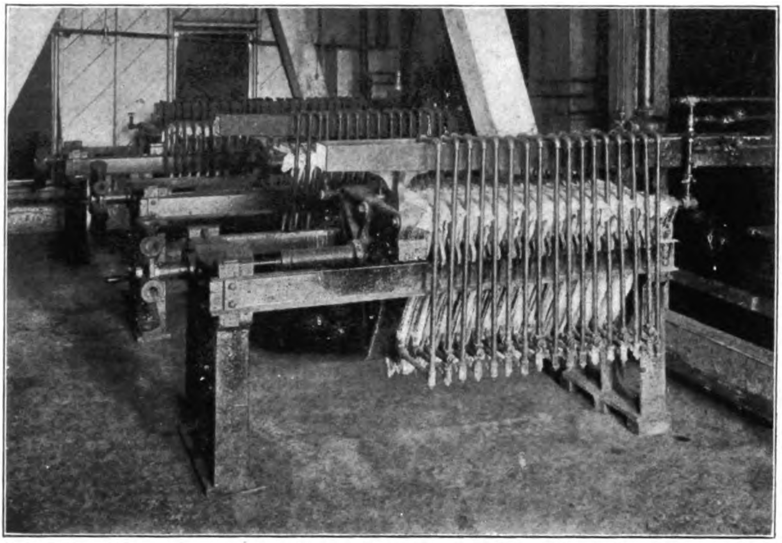


FIG. 10.—INSTALLATION OF MERRILL GOLD-PRESSES, SHOWING METHOD ADOPTED TO PREVENT THE DRAINING OF PRESSES.

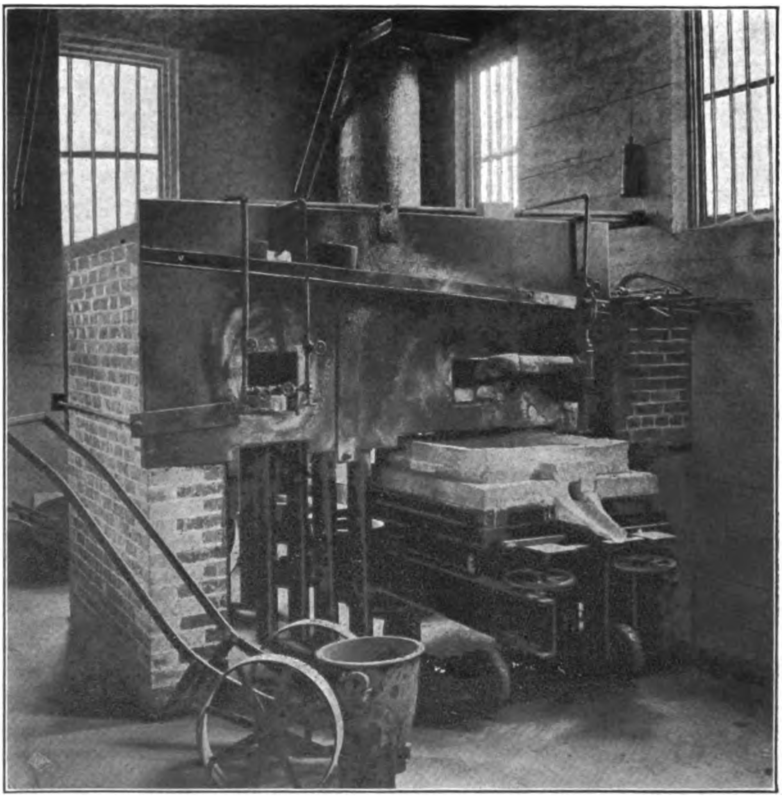


FIG. 11.—CUPELLATION-FURNACE IN USE AT ALASKA-TREADWELL, SHOWING CAR WITH TEST RUN OUT.

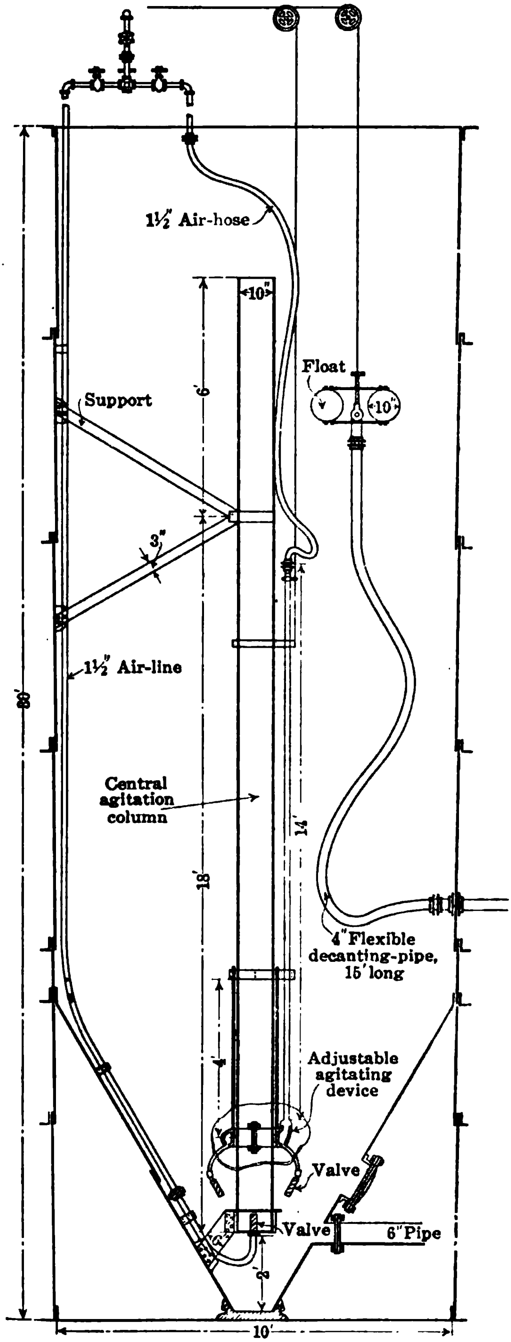


FIG. 6.—PACHUCA TANK.

packed mass in the bottom of the Pachuca. This is brought into thorough agitation within 15 min. by a device designated as the "spider," which is an adjustable hollow annular casting with radiating fingers, the whole encircling the central agitation-column.

When the charge is to be put into agitation the spider is lowered by a small hand-windlass until it rests on top of the settled charge. Air is then turned through the fingers, and at the same time the solution for the next treatment is run into the tank. The device rapidly bores its way to the bottom of the Pachuca, leaving a boiling, churning pulp above, and clearing the way to the bottom opening of the central 10-in. agitating-column. As soon as this is opened and air has been admitted to the inner-pipe the spider is raised from the tank and full agitation of the charge proceeds.

The second cyanide treatment of the charge is with solution drawn from the barren-solution storage-tanks or the wash-solution storage, the cyanide strength being 1.5 lb. (0.075 per cent.) per ton of solution. After 2 hr. of agitation the air is shut off and almost immediately decantation is started. This decanted solution is pumped directly on to an incoming fresh charge, being strengthened in cyanide as it enters the tank, and becoming the first cyanide solution for the new charge.

This cycle in handling solution—barren to wash-solution, then to second cyanide treatment at 0.075 per cent. cyanide, then to first treatment at 0.1 per cent. cyanide, thence to precipitation and back to barren—gives at each step just the conditions best suited for that step, and is very satisfactory in practical operation.

The settled pulp after the second decantation has a specific gravity of 1.8, and is readily agitated by means of the spider, and then discharged into the pulp-storage tank by a Byron-Jackson 4-in. centrifugal pump, from which it is drawn to the Kelly filter-press. This thick pulp holds in suspension the sands which would settle through a lighter medium.

The storage-tank is conical bottomed, 15 ft. in diameter, and situated at such an elevation that a static pressure of 30 lb. per sq. in. is exerted at the filter-presses. The pulp in the tank is kept in constant circulation by an air-lift, drawing from the conical bottom and carrying the pulp down close under the

filter-presses and back up again over the top of the tank. The pulp as pumped from the Pachuca tanks enters the bottom of this same line, and the whole is thus kept in suspension and circulation past the presses, into which it is intermittently drawn for filter-treatment. Fig. 7 shows the Kelly filter-presses installed to work under a gravity head as described.

Above the pulp-storage tank is placed a similar tank for the storage of wash-water, from which a hydrostatic pressure of 25 lb. per sq. in. is obtained at the presses. This solution is kept in circulation, using the same method as applied to the pulp. The higher gravity of the pulp in the lower tank results in a greater pressure at the presses than that obtained from the wash solution, although the latter carries a higher head.

Filtering is done in two type 1 B Kelly presses. By opening valves in the circulation-lines directly under each press it is filled with either pulp or wash-solution as desired. The excess pulp or wash-solution from the press-cylinder is returned into its proper line by displacing with compressed air admitted into the cylinder. The amount of wash given depends upon the comminution of the concentrates, the usual pulp being washed with 0.5 ton of solution per ton of concentrates. The cake formed during decantation of the first-treatment solution, being very fine slime and more impervious to wash-solution than the regular pulp, is given 1 ton of wash per ton of concentrates.

When filling the press, the contained air is allowed to escape through an overhead pipe attached to the highest point of the press-cylinder. The change in sound of the exhaust indicates to the pressman when the press is full. After drying the cake with compressed air until it contains not more than 10 per cent. of moisture, the press is opened and the cakes shaken off with wooden paddles, and then sluiced with water to the tailings-dam.

A distributor below the press-launder sends the gold-solution to two gold-sumps and the wash-solution to the two wash-solution storage-tanks. These four tanks, as well as a clarifying-tank which is in the same group, are built of 3-in. redwood, 15 ft. in diameter by 16 ft. deep, and each holds 75 tons of solution.

The wash-solution is pumped to a Pachuca tank as needed, becoming a second-treatment solution. From the gold-tank

the solution is drawn into the clarifying-tank, in which are suspended vertically six canvas filter-leaves, all connected to the suction of a triplex 7- by 9-in. Aldrich electric pump, used exclusively for pumping gold-solution through the precipitation-presses. A traveling-belt, driven by ratchet-gears and a pair of eccentrics connected to the pump-drive, feeds zinc-dust into a cone. Here the dust is emulsified with a small stream of gold-solution tapped from the discharge-column of the same pump, and is then drawn into the suction-line. An automatic float in the cone prevents the introduction of air into the pump-suction.

The pump raises the solution with the zinc-dust to the upper part of the building and forces it through two 36-in. triangular, 16-frame Merrill presses, Fig. 8. An average of 145 tons of solution is precipitated daily, with a consumption of $\frac{1}{8}$ lb. of zinc-dust per ton of solution, equivalent to 0.86 lb. of zinc-dust per ton of concentrates. The average strength of solution before precipitation is 1.25 lb. (0.0625 per cent.) of cyanide; 1 lb. (0.05 per cent.) of lime, and $9.50 (9.2 dwt.) gold. The barren or precipitated solutions are kept at 10 cents (2.3 grains), or less, gold per ton, and are used for wash-solution or returned to the Pachuca tanks, as desired.

The Merrill presses are opened when filled or when the pressure exceeds 25 lb. per sq. in. Forcing the solution through at higher pressures caused a mechanical loss of precipitate through the canvas. The precipitate is dropped from the press-frames into steel pans and lowered by an electric elevator to the floor below, and thence conveyed by trucks through a concrete passage into the refining-room.

IV. Cyaniding without Amalgamation.

On account of the work required to look after and collect the amalgam, as well as the greater danger of amalgam-loss from the pipe-lines, launders, etc., the plates were removed after the first three months' run, and the whole product is now being cyanided directly without amalgamation.

In order to handle the larger amount of solution made necessary when grinding in cyanide solution, two 1,800-ton steel tanks have been erected, one above and one below the plant. All the precipitated or barren solution flows by gravity from

the precipitation-presses to the lower tank. This solution, having an average value of $0.08 in gold, 1.14 lb. of cyanide, and 1.70 lb. of lime per ton, is pumped to the second of these tanks, which is situated 25 ft. above the mill-bins, and acts as the mill-reservoir.

Thus at no time is there any cyanide solution run to waste, the solution discharged as moisture in the tailings, plus that absorbed or evaporated in the mill, compensating for that received as moisture in the concentrates delivered to the bins.

All the solution used in grinding and classifying is drawn directly from the mill-reservoir. The overflow of fine pulp from the back of the Dorr classifier flows at once to the Callow tanks in the lower building, the spigot-product of which empties into one of the 12 Pachuca tanks for treatment.

The specific gravity of the pulp as it enters the Pachucas is 1.5, or a ratio of 1 of concentrates to 1.18 of solution. The charge is agitated for 8 hr., the necessary cyanide and lime being added to bring the cyanide-content of the solution to 1.5 lb. (0.075 per cent.) and the lime-content to 2 lb. (0.1 per cent.) per ton. After agitation and settlement, the clear solution is decanted to the gold-tank through the clarifying-press described later, and a fresh charge of barren solution, the same as that used in the grinding, is drawn from the mill-reservoir, brought to the same strength as the previous treatment, and the charge agitated for 4 hr. This is then settled and the solution is decanted. Both solutions decanted from the agitators, together with the overflow from the Callow settling-tanks previously mentioned, are drawn by gravity through the clarifying-press before emptying into the gold-tanks.

The settled pulp in the bottom of the Pachuca tanks, having a specific gravity of two, is then agitated by means of the spider and pumped to the pulp-storage tank, from which it is drawn to the Kelly presses for filter-treatment.

This method of operation, depending upon the one barren solution for all purposes, keeps the gold-content of the solution to the lowest possible value, which, although contrary to the usual practice, is the object sought in this mill.

The solution overflowing from the Callow settling-tanks (containing gold, $10; cyanide, 1 lb.; and lime, 2 lb. per ton) flows by gravity through a special clarifying-press built in the

Treadwell shops, the same as receives the decanted solution. This press is of the ordinary plate-and-frame type, yet with a series of ports or channels so arranged as to allow of discharging or sluicing-out a cake without the necessity of opening the press. This sluicing-out press consists of 20 square frames, each 3 in. thick, with the corresponding plates 1 in. thick. The upper and two side channels extending through the press have small holes opening into the frame side of the leaf. The upper small channel allows the introduction of compressed air behind the leaves. The lower triangular channel connects with a 6-in. sluicing-out pipe. The press, with connections, is shown in Fig. 9, with one of the plates standing to the left.

To discharge a cake, water is introduced at the back end of the press through the large triangular opening on the bottom, and flows through the underside to the discharge end, where it empties into the launder leading to the tailings-dam. With this passage-way clear, compressed air is introduced through the port-holes on the plate side of the leaf. The plate corrugations being depressed 0.5 in. leaves a concave surface, in which the cake forms. The air now being introduced behind the leaves by a series of separate knocks or bumps causes the cakes to drop off into the sluicing-out channel, where they are carried away by the stream of water.

For the final washing of the leaves, water is introduced through the three upper channels, and, passing through the tapered holes, is sprayed on the two filter-cloths, which bag together by reason of the compressed air introduced from the plate side.

The method of feeding the zinc-dust has been changed somewhat from that originally installed. The reasons for these changes were to create a more even feed of zinc, to do away with the air previously used in the emulsion-cone, and not only to break up any lumps, but to brighten the zinc and grind it even finer. To do this, the drive from the zinc-belt was taken from the Aldrich pump to a small counter-shaft, which was, in turn, belted to a worm-gear for the drive of the zinc-belt, the belt discharging its zinc directly into a small tube-mill 6 ft. long, made from 10-in. pipe, the cast-iron caps of which were turned to run in rollers. This tube is filled with rods of cast zinc 2 in. in diameter. These rods not only grind the zinc to

a more uniform product, but may themselves aid precipitation to a slight extent.

Considerable annoyance is occasioned by the clogging of the cloths in the Merrill gold-presses and by the accumulation of precipitate in the entire line from the zinc-feeder and pump to the presses. Filter-cloths of several kinds—heavy duck at 31 cents per yard, various grades of drilling at from 9 to 15 cents, and muslin sheeting at 7 cents—have been tried. The lightest and cheapest muslin is now in use, with results no worse than obtained with the more expensive grades.

From the moment of contact of the zinc-dust with the gold-solution trouble is caused by the slimes or precipitate incrusting everything touched. The interior of the pipes gradually becomes smaller in area, even though the solution is driven through at a constantly increasing velocity. After three months' use a 6-in. pipe of 28 sq. in. area was so filled with caked precipitate that only a triangular opening of 4 sq. in. remained. From 80 ft. of this pipe, $25,898 was recovered.

Being desirous of operating the Merrill presses more or less intermittently without the necessity of each time closing the cocks to retain the solution, which if allowed to drain not only oxidizes the zinc, but causes the precipitate when the pressure is removed to settle in a mass at the bottom of the press-frames, consequently not allowing the greatest amount of solution to pass through the unoxidized zinc, the discharge-cocks were removed from the plates, and open pipes discharging into a launder on top of the presses were substituted, as shown in Fig. 8.

The result of the several changes is a more uniformly low tail solution, with the consumption of less zinc, while the gold-value of the precipitate has been raised from $15 to $25 per pound; hence a corresponding lowering of refining-charges.

V. The Refinery.

The refinery adjoining the mill is 30 by 76 ft. in area; constructed of reinforced concrete with steel-truss roof covered with corrugated iron, shown in Fig. 10. The precipitate entering the refinery is crushed through 0.5-in. screen, made up into lots of from 1,000 to 1,200 lb., weighed, sampled, and charged into one of two redwood tanks, 8 ft. in diameter and 9 ft. deep,

conical bottomed and lined with sheet lead. The tanks are built on the plan of a Pachuca tank, with a central column of wood fitted with lead pipes carrying steam and compressed air for heating and agitating the solutions.

In these tanks the precipitate is treated with acid to dissolve out the zinc, lime, etc. About 1 lb. of 66° sulphuric acid is required per pound of precipitate, and is added in the following manner: About 2 tons of water is introduced into the tank, steam turned on, and the water brought to the boiling-point. Air is turned on in the central air-lift, and the acid-valve opened. The acid flows in by gravity, while the precipitate is shoveled in at the rate of 2 lb. of precipitate to each pound of acid. When all the precipitate and from 50 to 60 per cent. of the acid have been added, the acid-valve is closed and the charge agitated until the acid is entirely neutralized, which generally occurs within 30 min. The tank is then filled with water, and the charge allowed to settle for about 2 hr., after which the clear solution is siphoned off into a filter-tank. The latter is 8 ft. in diameter and 4 ft. deep, having a false bottom of 1-in. strips, placed 12 in. from the bottom of the tank and 1.5 in. apart. The strips are covered with heavy iron screen, 1-in. mesh, on which is a bed of burlap 1 in. thick, one thickness of mill blanket, one thickness of light canvas, and a bed 1 in. thick of quartz sand screened between 20- and 80-mesh. The sand is divided into sections of 8 by 10 in. by a light wooden frame, covered by a single thickness of drilling, the latter forming the working-surface of the filter. The solutions filter freely through this medium, the clear filtrate being run into one of three storage-tanks, where it is held until a sample has been assayed, and then run to waste through a series of zinc-boxes. All solutions and wash-waters from the refinery are disposed of in this way.

After decanting the first acid the precipitate in the tank is given two washes of boiling water. Just enough water to enable the charge to be agitated is then added, and the remainder of the acid run in rapidly. This gives a solution containing from 15 to 18 per cent. of acid, agitation being continued until the acidity ceases to decrease, which usually leaves about 1 per cent. of free acid. The tank is then filled with water, settled

and decanted as before. This solution, containing from 50 to 75 lb. of free acid, is at present run to waste.

The charge now receives three or four washes of boiling water followed by washes at about 30° C. temperature, until the wash-water gives no reaction for sulphates with barium chloride, which is generally after 15 washes. After decanting the last wash, the charge is sluiced through a valve in the bottom of the tank on to the filter, which has been thinly covered with silica sand to aid filtration, where the excess water is removed by means of a vacuum-pump. The slimes are removed to a large wrought-iron pan, placed upon a 4- by 8-ft. steam-table, inclosed by a sheet-iron hood. When nearly dry but still damp enough to prevent dusting, the slimes are rubbed through a 0.5-in. screen, weighed and sampled, the weight of the acid-treated product being from 25 to 33 per cent. that of the original precipitate. Each lot of precipitate is analyzed before and after the acid treatment, which enables a close calculation to be made of the amounts of fluxes required for the monthly melting.

The percentages of the principal substances contained in an average analysis of the precipitate before and after acid treatment are:

	Before. Per Cent.	After. Per Cent.
Au	5.08	17.34
Zn	42.93	5.15
Pb	8.08	20.09
Cu	6.19	14.28
Cao	10.51	1.89
Fe	1.10	0.52
S	1.41	7.62
Insoluble,	3.48	22.85

The high percentage of insoluble after treatment is due to the silica added to the lot just before filtering.

At the end of the month the various lots of acid-treated precipitate are united and the various fluxes added. The melting is done in a specially-constructed oil-burning furnace (Fig. 11). For melting purposes the furnace is fired with a reducing flame. The crucible or hearth used for the melting is 4 by 3.5 ft., lined with either magnesite brick or fire-clay, according to the fluxes used. This hearth is placed on a steel car and run

under the furnace. Jack-screws, operated by hand-wheels at the four corners of the car, allow of raising the hearth to form the furnace-bottom.

From the fire-box at one end of the furnace the heat is drawn across the top of the charge, being reflected downward by the arch roof and the down-draft to a dust-condensing chamber. The furnace is charged with precipitate hourly, the slag and lead-bullion being tapped off intermittently from opposite sides of the hearth. The month's clean-up, amounting to 1,450 lb. of acid-treated precipitate, or a total charge, including fluxes, of 2,600 lb., is melted on this hearth in 36 hr., and requires the attention of but one man per shift.

A typical mixture of fluxes is:

	Pounds.
Acid-treated precipitate,	100
Borax glass,	22
Sodium carbonate,	25
Old slag,	80
Iron-turnings,	15
Powdered graphite (old retorts),	3

Such a charge will produce about 35 lb. of metal, from 10 to 15 lb. of matte, and from 160 to 180 lb. of slag.

From 150 to 300 lb. of high-grade copper-matte are produced each month. This matte is roasted and allowed to accumulate until there is sufficient to make up a charge, when it is mixed with litharge, fluxed, and melted to produce lead-bullion, which is the work-lead used for the removal of copper in cupellation.

After melting either precipitate or matte, the slag is tapped into conical pots holding about 200 lb., with a tap 4 in. from the bottom, through which the molten core is drawn off. The shells, containing most of the metallic values, are dumped, crushed, and used in fluxing a later charge. The cores, constituting 75 per cent. of the total slag, are sampled, sacked, and stored for shipment to the smeltery.

The cupellation is done on a limestone test the same size as the melting-hearth, it being run under the furnace on the car previously described. For cupellation the furnace is fired with an oxidizing flame, while free air is introduced over the test by means of a connection from a compressed-air main through a needle-valve discharging into the open end of a

4-in. pipe. This produces low-pressure air, which is introduced into the furnace on the opposite side from which the molten litharge is tapped off.

The fine bullion resulting from this cupellation is drawn off and remelted in Faber du Faur tilting-furnaces into bars of 1,000 oz. each. The average fineness of the cupelled gold is 880.

The retorts of the Faber du Faur furnaces are supported on two 1.5-in. iron pipes built into the furnace, through which cold water is kept circulating. These pipes have proved very satisfactory.

VI. Costs.

In conclusion, the cyanide-plant has now been in operation one year, using the machines and equipment originally installed, with the exception of the abandoned amalgamation-plates, the substitution of larger tube-mill motors, and the addition of the "Treadwell" clarifying-press, with results summarized in Table VI.

For the last month, ending August 15, and not included in cost-sheet, 2,010 tons were treated, at a cost of $2.8764 per ton, and an estimated extraction of 97.025 per cent., as compared with the experimental estimates of $3.25 per ton and 96 per cent. extraction.

TABLE VI.—*Costs of Cyanide-Treatment, Alaska-Treadwell Gold Mining Co.*

First period. Treatment: Regrinding and amalgamation, followed by agitation in cyanide solution. Period covered: Sept. 16 to Dec. 20, 1910; trial run and first adjustments of the plant. Average head value: $54.6174. Average tailing value: $1.7589. Estimated extraction: 96.80 per cent. Tons treated: 4906.1.

Operation.	Costs Per Ton Treated.					
	Labor ([d]).	Electric Power, ([c]) Compressed Air, Steam Heat.	Supplies. Item.	Supplies. Cost.	Sundry Supplies.	Totals.
Grinding	$0.2033	$0.6179	Pebbles 8.05 lb.	$0.1182	$0.0449	$0.9843
Amalgamation	0.2324	0.0009	Mercury 3.3 oz.	0.1516	0.0066	0.3915
Cyaniding	0.3291	0.1378	Lime 19.78 lb.	0.1978	....	....
			Cyanide 2.46 lb.	0.5163	0.0201	1.2011
Filtering	0.3389	0.0791	....	....	0.0233	0.4416
Precipitation	0.1549	0.0645	Filter cloth	0.0162	0.0053	0.3001
			Zinc-dust 0.79 lb.	0.0592		
Refining ([a])	....	....	....	....	....	....
Analyses, assays, accounting ([b])	....	....	....	....	0.1780	0.1780
Superintendence	0.1936	....	....	....	....	0.1936
Repairs	....	0.0811	....	....	0.0179	0.0990
Totals	$1.4522	$0.9816		$1.0593	$0.2961	$3.7892

Second period. Treatment: Regrinding in cyanide solution, followed by agitation in cyanide solution. (No amalgamation.) Period covered: Feb. 16 to May 15, 1911. (Plant idle Dec. 21, 1910, to Feb. 15, 1911.) Average head value: $46.9360. Average tailing value: $1.7990. Estimated extraction: 96.17 per cent. Tons treated: 4620.6.

Operation.	Costs Per Ton Treated.					
	Labor ([e]).	Electric Power, ([c]) Compressed Air, Steam Heat.	Supplies. Item.	Supplies. Cost.	Sundry Supplies.	Totals.
Grinding	$0.1512	$0.4679	Pebbles 22.19 lb.	$0.2686	$0.0061	$0.8939
Amalgamation	....	....	....	....	....	....
Cyaniding	0.2646	0.1007	Lime 12.77 lb.	0.1226		
	....	....	Cyanide 2.86 lb.	0.5665	0.0251	1.0795
Filtering	0.2646	0.0729	Press-cloth	0.0109	0.0053	0.3537
Precipitation	0.1843	0.0567	Zinc-dust 2.16 lb.	0.1635	....	
			Filter-cloth	0.0204	....	
			Lead acetate 0.54 lb.	0.0511	0.0134	0.4894
Refining ([a])	0.2268	0.0436	Retorts	0.0619		
			Sulphuric acid	0.0617	0.0252	0.4192
Analyses, assays, accounting ([b])	0.1269	....	....	....	0.1687	0.2956
Superintendence	0.1890	....	....	....	....	0.1890
Repairs	0.1118	....	....	....	0.0069	0.1187
Totals	$1.5492	$0.7418		$1.3272	$0.2507	$3.8689

Third period. Treatment: Regrinding in cyanide solution, followed by agitation in cyanide solution. (No amalgamation.) Period covered: May 16 to July 15, 1911. Average head value: $55.4899. Average tailing value: $1.8892. Estimated extraction: 96.60 per cent. Tons treated: 4080.

Operation.	Costs Per Ton Treated.					
	Labor ([e]).	Electric Power, ([c]) Compressed Air, Steam Heat.	Supplies. Item.	Supplies. Cost.	Sundry Supplies.	Totals.
Grinding	$0.1196	$0.1279	Pebbles 13.55 lb.	$0.1776	$0.0059	$0.4310
Amalgamation	....	....	....	....	....	....
Cyaniding	0.2093	0.0396	Lime 7.06 lb.	0.0649		
	....	....	Cyanide 2.49 lb.	0.5330	0.0018	0.8486
Filtering	0.2093	0.0346	Filter-cloth	0.0038	0.0059	0.2536
Precipitation	0.1458	0.0234	Filter-cloth	0.0103		
			Zinc-dust 2.09 lb.	0.1700		
			Lead acetate 0.15 lb.	0.0142	0.0209	0.3846
Refining ([a])	0.2243	0.0243	Fluxes	0.0193		
			Sulphuric acid	0.0656	0.0501	0.3836
Analyses, assays, accounting ([b])	0.0748	....	Chemicals	0.0142	0.0476	0.1366
Superintendence	0.1495	....	....	....	....	0.1495
Repairs	0.1121	....	....	....	0.0274	0.1395
Totals	$1.2447	$0.2498		$1.0729	$0.1596	$2.7270

([a]) During the first period the refinery had not been completed and the precipitate was shipped to a smelter, cost of which is not given.
([b]) Assays are made at the central assay office of the combined companies at Treadwell, and charged against the cyanide plant at a proportionate rate per assay.
([c]) Electricity, compressed air, and steam are purchased from central power plants, at cost of generation.
([d]) Labor, first period, 20 men at $3.75 average wage.
([e]) Labor, second and third periods, 22 men at $3.784 average wage. (18 men in mill, 4 men in refinery.)

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Geology of the Tonopah Mining-District.

BY AUGUSTUS LOCKE, GOLDFIELD, NEV.

(San Francisco Meeting, October, 1911.)

Two Opposed Interpretations of the Tonopah Structure.—The important geological publications concerning the Tonopah mining-district are those of Spurr[1] and of Burgess.[2] In these publications are presented fundamental differences of interpretation, which are the more interesting because both authorities have had ample opportunity for observation, and because both are geologists of proved ability. I was vastly puzzled to know which had the better of it, and in order that I might reach a conclusion in my own mind, I recently spent some time in the district going over the physical evidence. Surprising as it may seem, this evidence looks agreeably conclusive. A review of it will, I believe, be of interest to those who are familiar with the previous publications.

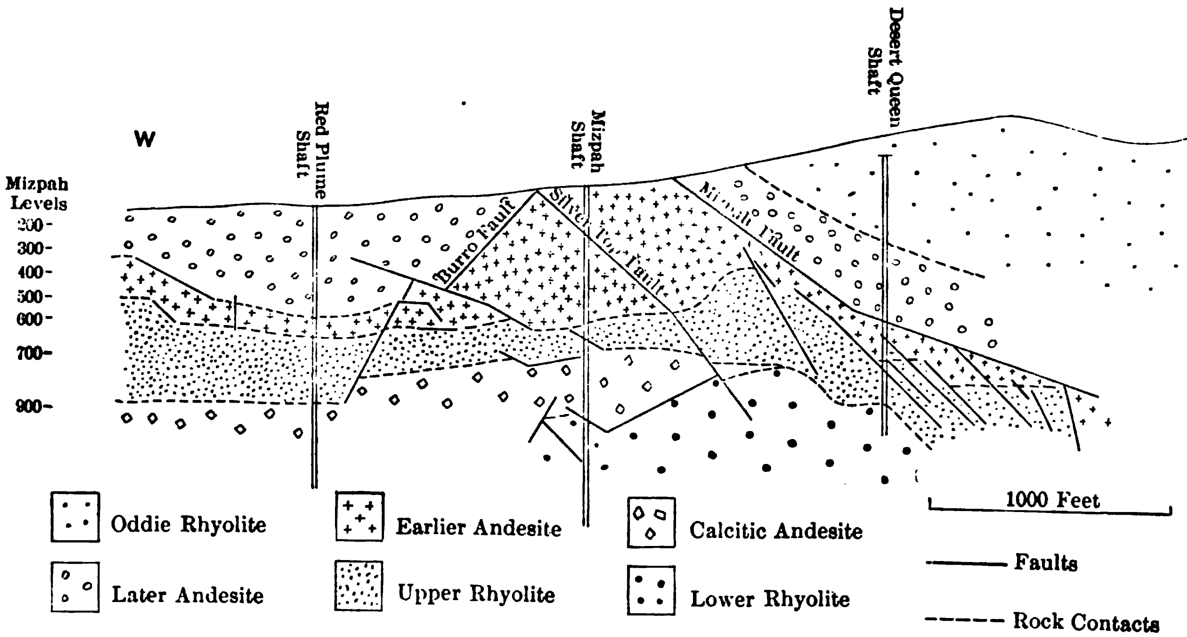
The general geological features of Tonopah are shown in Fig. 1, and the differences of interpretation referred to are outlined in the accompanying notes. Briefly, Burgess regards the various rocks as flows, lying in the order of their deposition. Spurr regards them in part as flows, and in part as flat-lying intrusives. The disagreement, then, concerns the rocks regarded on the one hand as intrusives, and, on the other hand, as flows. These rocks are chiefly the so-called calcitic andesite, the upper rhyolite, and the lower rhyolite.

Economic Importance of the Question of Interpretation.—The economic importance of the question of interpretation is, of course, limited to its bearing on the probable distribution of

---

[1] Geology of the Tonopah Mining District, Nevada, *Professional Paper No.* 42, *U. S. Geological Survey* (1905). *Report on the Geology of the Property of the Montana-Tonopah Mining Co.* (1910). An abstract of this report is given in the *Mining and Scientific Press*, vol. cii., No. 16, p. 560 (Apr. 22, 1911).

[2] The Geology of the Producing Part of the Tonopah Mining District, *Economic Geology*, vol. iv., No. 8, pp. 681 to 712 (Dec., 1909).



Geologic column of rocks shown in section (youngest at top).

Spurr (1910).	*Burgess.*
Oddie rhyolite (partly intrusive).	Oddie rhyolite.
Lower rhyolite.	Later andesite.
Later andesite. } probably	Earlier andesite.
Calcitic andesite (intrusive). } identical.	Upper rhyolite.
Upper rhyolite (intrusive).	Calcitic andesite.
Earlier andesite.	Lower rhyolite.

FIG. 1.—EAST-WEST SECTION THROUGH MIZPAH SHAFT.

Adapted from section by Burgess, *Economic Geology*, vol. iv., No. 8, p. 684 (Dec., 1909) Facts indicated by this section constitute one of the chief arguments in favor of the hypothesis that the rocks are flows, lying in the order of their deposition.

undiscovered ore. The later andesite is generally conceded to be barren—a "cap rock," at whose lower contact the productive veins apex. The earlier andesite has so far yielded the bulk of the production. As has been already suggested, both Spurr and Burgess regard it as a flow, and both have essentially the same conception of its distribution. Above the bottom of the earlier andesite, therefore, the conception of the ore-distribution is the same, whichever interpretation be adopted.

Below the bottom of the earlier andesite, however, the matter of interpretation assumes supreme economic importance; for, while Burgess regards all the underlying rocks as older than the earlier andesite, and older than the chief ore-mineralization, Spurr regards them as younger than both. Under Spurr's hypothesis, exploration in these rocks is emphatically discouraged; under Burgess's, it is to a certain extent encouraged.

Outline of the Evidence.—The important evidence appearing to favor the hypothesis that all the rocks occur in flows is as follows:

1. The locus of each rock is horizon-like. For example, the lower rhyolite is encountered at depths averaging about 1,000 ft., over an area of at least a square mile. Its surface, except where it is faulted, is seldom steeper than hill slopes, and is chiefly flat or horizontal.

2. Materials closely resembling stratified volcanic tuffs occur abundantly on the upper contact of the lower rhyolite, and less abundantly on the upper contact of the upper rhyolite.

3. The contacts between the supposedly intrusive and intruded rocks are, when unfaulted, most often notably straight and regular. Nowhere have the so-called intrusives been conclusively proved to invade by means of offshoots the rocks which they have supposedly intruded. The interpretation of irregularities of contact as proof of intrusion is made difficult by the abundant faulting, and by the possibility of inter-flow erosion.

4. The andesitic cover has, over a large area, rigidly confined the rocks which underlie it. The lower rhyolite, a rock having a very characteristic and unmistakable appearance, has been proved to occur on the surface only in the territory considerably north of the producing mines, and there in very small and scattered bodies which may be inclusions.

5. The productive veins in certain places pass without diminution either in size or richness from the earlier andesite down into the upper rhyolite.

6. In many places near the top and near the bottom of the upper rhyolite, there occurs an extraordinary igneous breccia, often many feet thick and crowded with foreign inclusions; the matrix is rhyolitic, and the rock looks exceedingly like a flow breccia. The upper portion of the lower rhyolite has numerous but less abundant inclusions.

7. The rhyolites, though containing abundant inclusions, and among them some which are andesitic, have never yielded inclusions which can be positively identified as belonging to the earlier or later andesites.

8. The andesites are free from inclusions of all sorts; therefore their freedom from inclusions of rhyolite is no indication that they are older than the rhyolites.

The evidence supposedly favoring the hypothesis that some of the rocks are intrusive is as follows:

1. In the rhyolites, a banding resembling flow structure sometimes follows irregularities in the contact:

2. The rhyolites occasionally have on their contacts with the andesites knob-like and wedge-like projections, looking like intrusive shapes.

3. In certain places, the calcitic andesite is separated by rhyolite from the later andesite with which it is supposed by Spurr to be identical. In certain places, the earlier andesite is separated by upper rhyolite from a rock called glassy trachyte, with which Spurr supposes it to be identical.

4. The profitable veins often disappear or weaken when they reach down to the lower contact of the earlier andesite.

The Evidence Afforded by the General Distribution of the Rocks.— It must be granted at the outset that the disposition of the rocks in horizons creates the presumption that they are flows. Most of the shafts penetrate similar rocks in similar succession. Thus, the lower rhyolite, so far as is known, underlies the whole district; the calcitic andesite almost everywhere covers the lower rhyolite; and above these rocks come, in order, the upper rhyolite, the earlier andesite, and the later andesite. The individual sheets of rock have many irregularities in

thickness; these, however, are satisfactorily attributable to inter-flow erosion and to faulting.

Again, if we conclude that the earlier andesite is the oldest rock in the district, we must conclude also that it has been floated up by the intrusive underlying rocks to a height of at least 1,000 ft., and possibly to a much greater height. (The lower contact of the lower rhyolite is not known.) During the process of floating up, the andesite has retained over an area of at least a square mile, its integrity and approximate horizontality.

A general view, then, of the large features of rock-distribution affords strong evidence in favor of the theory of extrusion. Nevertheless, it is conceivable that pseudo-flows might result from intrusion, and this evidence is therefore, by itself, inconclusive.

The Evidence Afforded by the Supposed Tuffs.—If the large facts of rock-distribution fail to furnish conclusive evidence of the origin of the rocks, this evidence must be sought in the details of the rock-contacts.

In general, there are certain details of rock-contacts whose testimony must be accepted as unimpeachable. One such detail is the existence at contacts of volcanic tuffs; genuine tuffs being proved to exist between layers of volcanic rocks, it is difficult to conceive of evidence, however abundant, which would prove that the layers are not flows.

It becomes, therefore, a matter of extreme importance to determine whether or not in Tonopah the supposed tuffs are genuine. Burgess, who discovered them, believes that they are. Spurr believes that they are not.

That they are tuff-like, is beyond doubt. They are somewhat soft; they possess stratification, marked by alternating bands of coarse and fine fragmental material; they cleave easily along the junctions of these bands; they lie with their structure parallel with the rock-contacts.

If they are not true tuffs, resulting from surface deposition, then they are conceivably attributable to one or both of two processes—flow-banding (the arrangement of inclusions along flow-lines) and movement-banding. Spurr's conception of their origin is expressed in the following: ". . . brecciated and granulated rock is often layered by the fault-movement and

fault-pressure, so that it assumes all the appearance of certain varieties of surface-formed detrital tuffs."[3]

Microscopic examination of thin sections of specimens from the Mizpah 700-ft. level yields conclusive evidence against the possibility of the production of the supposed tuffs either by flow-banding or movement-banding. (1) The tuffs are made up of sharp-cornered fragments, often crowded closely together, and are typically clastic. (2) They are distinctly layered; layers of coarse material alternate with layers of fine material, with no gradation from coarse to fine. (3) The abundant quartz phenocrysts, with one or two exceptions, when revolved in polarized light, extinguish with much suddenness. The wavy extinction, which is the invariable characteristic of strained quartzes, is strikingly absent.

That a sorting out and sharp separation of coarse from fine should result from flow- or movement-banding, is, of course, incredible. And the significance of the unstrained quartz phenocrysts cannot be questioned. Indeed, the tuffs are so life-like and their detrital origin so obvious that their import would be ordinarily accepted without question.

The Supposedly Intrusive Contacts.—The supposedly intrusive contacts of rhyolite with other rocks at no place seen by me offer incontestable evidence of intrusion. Before such proof can be accomplished, it is necessary to prove that the irregularities were not caused by faulting, or by inter-flow erosion, or by both. Now, in localities of extensive rock-alteration and abundant faulting, such proof is impossible; indeed, here the proof that the irregularities were actually caused by faulting is frequently possible.

The rhyolite at certain places possesses a banding which follows to some extent irregularities of the contact, and which sometimes looks like flow-banding, and might suggest intrusion. I have failed, however, to find any such place where the evidence of intrusion was unequivocal. Usually, the banding is irregular and very discontinuous. It is quite as often oblique to the contact as parallel with it. Moreover, if contact-movement, as Spurr believes, can produce tuffs, it is very easy to conclude that it can produce apparent flow-structures.

[3] *Report on the Geology of the Property of the Montana-Tonopah Mining Co.* (1910).

Evidence Afforded by the Localization of the Profitable Ore-Deposits.—The usual localization of the profitable ore-deposits to the earlier andesite is one of the most interesting facts of ore-occurrence with which I am familiar. In certain cases, the ore ends abruptly when it comes down to the lower contact of the andesite. In other cases, it extends down into the underlying rhyolite, ultimately, however, weakening and dying out. Occasionally, see Fig. 2, it survives for a time with a hanging-wall of andesite and a foot-wall of rhyolite, ceasing shortly after it passes entirely into the rhyolite. Lastly, it passes from andesite to rhyolite without change.

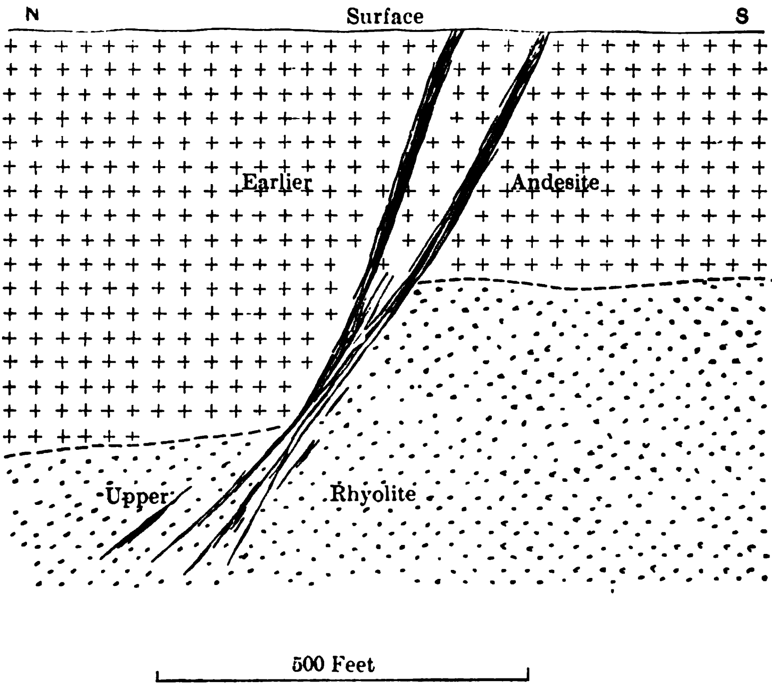


FIG. 2.—VERTICAL CROSS-SECTION SHOWING DOWNWARD EXTENSION OF TYPICAL VEIN INTO RHYOLITE.

To explain the superior productivity of the andesite, many hypotheses are possible: (1) The andesite is the earliest rock; the chief ore-mineralization followed it and preceded the other rocks. (Spurr's hypothesis.) (2) The source of the ore-minerals may have been the andesite itself or the upper rhyolite.

(Suggested by Burgess.) (3) The ore was deposited largely by metasomatism. The various rocks, particularly the upper rhyolite and the earlier andesite, present great contrasts in texture. Certain textural and chemical properties possessed by the andesite caused it to be more favorable to the precipitation of the ore-minerals than the other rocks. Or the andesite was more favorable to the formation of initial channels than the other rocks. (4) The path of travel of transporting-agents was mainly along the andesite-rhyolite contact and upward into the andesite. (5) Ore-deposition was a superficial phenomenon, effected through the decrease of heat and pressure near the surface, or through other superficial agencies. The andesite, at the time of ore-deposition, was the surface-rock, and, therefore, received the bulk of the ore-mineralization. (6) Post-vein faulting at the contact between upper rhyolite and lower andesite in some instances caused the disappearance of the vein at the contact. (7) Ore-mineralization occurred after the eruption of the earlier andesite and in cooling-shrinkage cracks in that rock.

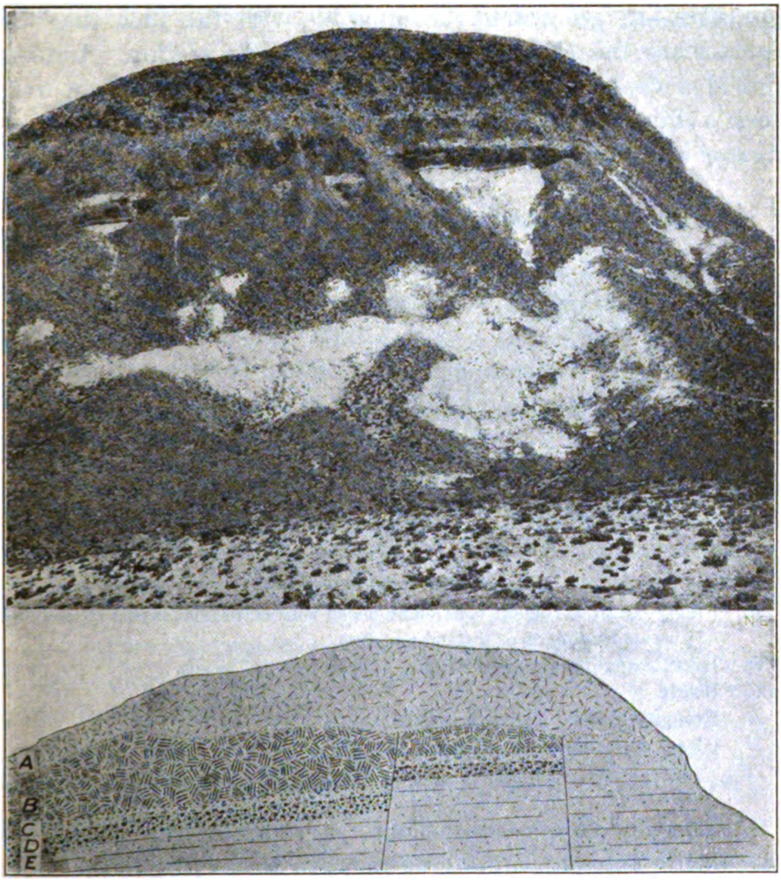
Spurr, as has been already made clear, accepts the first of these hypotheses and, apparently, rejects the others. The fact that the ore frequently extends down into the rhyolite, he explains by a supposition of several periods of mineralization, of which the first and most important was earlier, and the others later, than the rhyolite. Veins contained entirely in andesite belong, then, to the first period; veins in rhyolite, or in both rhyolite and andesite, belong to later periods.

That several periods of mineralization did exist is probably true. The assignment, however, of a particular vein to a particular period is often impossible. There is no mineralogical distinction whatever to be made between many veins which, according to the hypothesis, should belong to separate periods, and the sole apparent reason why one should assign them to separate periods is that, by so doing, he harmonizes the facts with the theory of rock-intrusion.

The remaining six hypotheses cannot be easily cast aside. To prove any one of them would be difficult; to disprove, it would be even more difficult. Yet so long as they stand as possible explanations of the localization of the ore-deposits,

they must offer impassable barriers to the acceptance of the hypothesis just now considered.

The Structure of Siebert Mountain.—Though it can have only an indirect bearing on the subject at hand, a consideration of



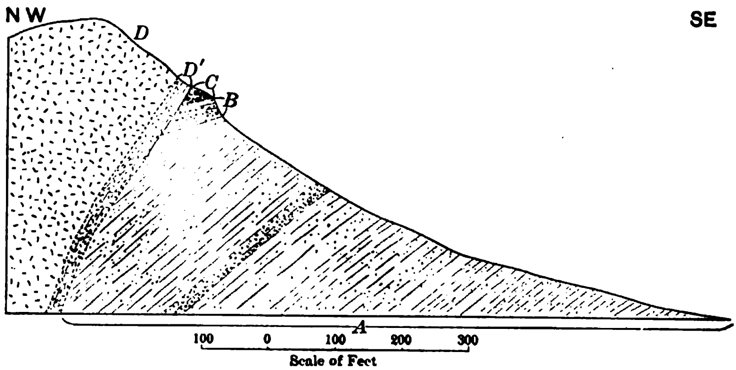
(From *Professional Paper No.* 42, *U. S. Geological Survey.*)

A. Later intrusive dacite.
B. Basalt.
C. Pumice agglomerate.
D. Basalt agglomerate.
E. White tuffs (lake-beds).

FIG. 3.—FACE OF SIEBERT MOUNTAIN, FROM THE SOUTHEAST.

the structure of Siebert mountain, situated several miles SW. of Tonopah, will illustrate in a specific instance the wide differences in opinion produced by the differences in interpretation here being discussed.

Siebert mountain looks like a succession of flows, Fig. 3. But Spurr's interpretation, shown in Fig. 4, regards it as partly intrusive. The fact of the matter is, however, that the supposedly intrusive rhyolite (or dacite), just above its contact with the basalt, has a very well-marked and nearly horizontal flow-structure—a fact scarcely compatible with the idea that the contact has the character shown in Spurr's section. Indeed, this idea would seem to be the result of *a priori* reasoning, were such a thing not manifestly impossible in the case of an investigator of Spurr's eminence and acumen.



(From *Professional Paper No.* 42, *U. S. Geological Survey.*)

A. Finely-stratified Siebert tuffs (lake-beds) with occasional layers of rounded pumice fragments or water-worn lava.
B. Basaltic agglomerate with bombs, capped by solid basalt.
C. Basalt.
D. Brougher dacite, intrusive neck.
D'. Glassy marginal facies of dacite.

Fig. 4.—Vertical Cross-Section of SE. Side of Siebert Mountain.

Summary of Conclusions.—That the rocks of the productive part of the Tonopah mining-district are flows lying in the order of their deposition, is proved by the occurrence of volcanic tuffs at the contacts whose interpretation has been in dispute. The other available evidence in some instances supports, and in no instance contradicts, this conclusion. There is no good reason, then, for the belief that the rocks underlying the earlier andesite are younger than the chief productive mineralization. Exploration in these rocks is accordingly relieved of the discouragement which would attend this belief.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Fritz Engineering and the Coxe Mining Laboratories of Lehigh University.

BY JOSEPH DANIELS,* SOUTH BETHLEHEM, PA.

(San Francisco Meeting, October, 1911.)

I. The Fritz Engineering Laboratory.

THE Fritz Engineering Laboratory was built under the direction of John Fritz, and presented by him to the University. A view of the building, looking east, is shown in Fig. 1. The building was started in 1909, and completed in 1910, although all of the equipment was not placed until later. Mr. Fritz gave his personal attention to the details of construction and equipment, and it was his custom to drive over every day to the University from his home in Bethlehem, and spend some hours watching the work, offering suggestions, making changes, and planning new work. The result is a building and an equipment which embody his practical ideas.

The laboratory structure is of the steel mill-building type, of light-colored brick, 91 by 114 ft., of which a section is shown in Fig. 2 and the floor-plan in Fig. 3. The steel frame carries the roof and traveling crane-way. Ample light has been provided by numerous windows in the side and end walls, in the clerestory, and by a skylight, 84 ft. long and 9 ft. wide, in the north roof. The main aisle of the building is 49 ft. 2 in. between centers of crane-columns, and has a clear height of 40 ft. The remainder of the width is taken up by two side aisles, 18 ft. high.

The laboratory consists of four sections: (1) A general testing-section, containing the testing-machinery, a small machine shop, and an office; (2) a cement-testing room; (3) a room for making and storing concrete test-specimens; (4) a hydraulic section.

* Associate Professor of Mining Engineering.

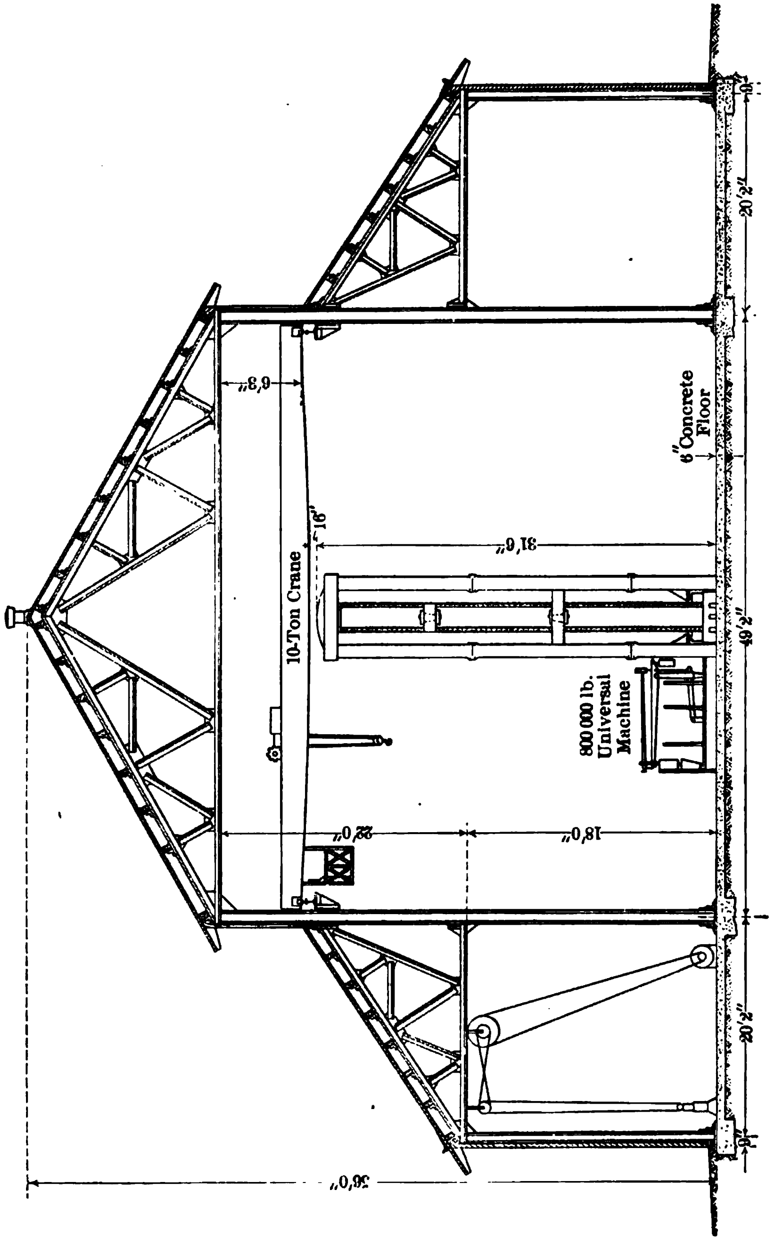


FIG. 2.—SECTION OF FRITZ ENGINEERING LABORATORY.

1. *The Testing-Section.*

This section, Figs. 4 and 5, occupies the larger part of the western end of the building, and contains all of the testing-machines except the briquette-machines, which are in the cement section. For facility in handling the test-specimens, a 10-ton crane, 47 ft.

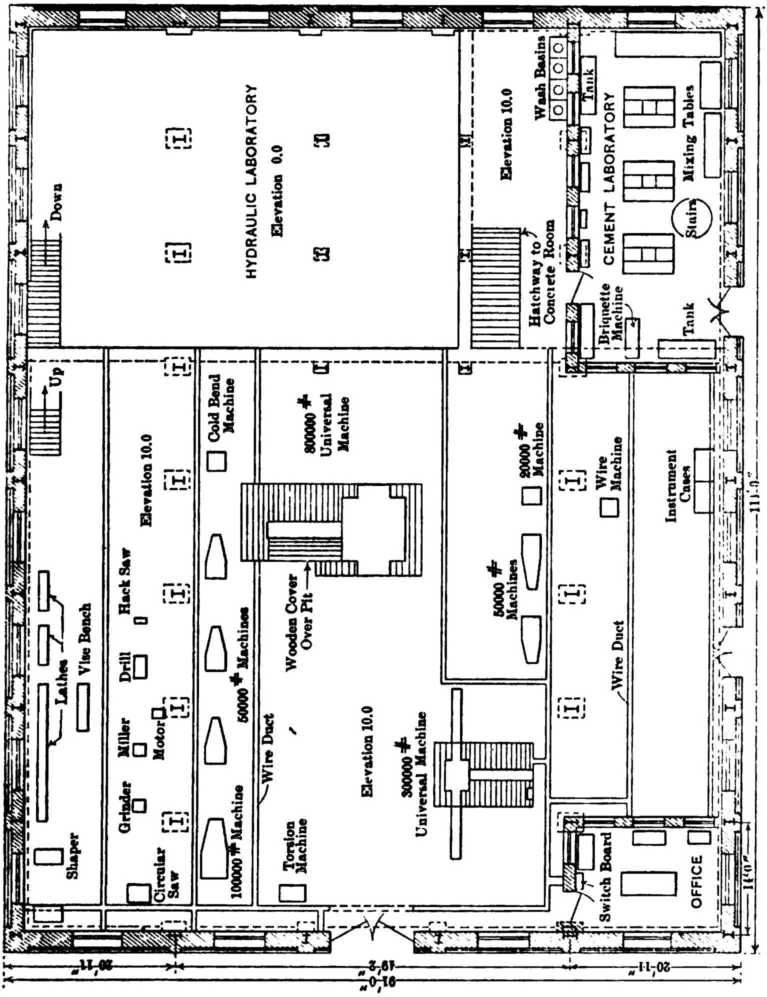


FIG. 3.—FLOOR-PLAN OF FRITZ ENGINEERING LABORATORY.

2 in. center to center of runway beams, operated by three direct-current motors, has been provided. A small machine-shop, containing a drill-press, lathe, milling-machine, shaper, etc., operated by a 7.5-h-p. motor, is available for general repair-work.

The principal equipment of the testing-section proper is as follows:

Type of Machine.	Capacity in Pounds.
Universal,	800,000
Universal,	300,000
Universal,	100,000
Universal,	50,000
Universal,	50,000
Universal,	50,000
Universal,	50,000
Universal,	50,000
Tension and compression,	20,000
Wire tester,	20,000
Cold bend, 1.5 in. diameter bar.	
Torsion, 24,000 in. pounds.	

2. *The Cement-Testing Room.*

The cement-testing section occupies a separate room on the main floor. The equipment consists of tables for making cement specimens, storage-tanks, briquette-testing machines, and apparatus for making standard cement-tests.

3. *The Concrete-Room.*

The concrete-room is under the cement-room, and is used for preparing cubes, beams, and cylinders. It is connected with the main testing-room by a hatchway, through which the heavy specimens may be hoisted into the main room by the crane. The equipment consists of bins for sand and stone, mixer, and molds.

4. *The Hydraulic Section.*

The hydraulic section occupies the NE. portion of the building. The lower floor is 10 ft. below, and the second floor, or elevated platform, 10 ft. above, the testing-room level.

The equipment on the lower floor consists of

1 DeLaval centrifugal pump, 2,000 gal. per min. against 60 ft. head.
1 Atlantic Hydraulic Machinery Co. centrifugal pump, 200 gal. per min. against 255 ft. head.
1 steel pressure tank—65.25 in. in diameter by 34 ft. 6 in. high.
2 steel calibrating-tanks—8 ft. in diameter by 12 ft. high.
3 steel weighing-tanks—4 ft. in diameter by 3 ft. high.
1 steel Weir tank—4 by 4 by 21 ft. long.
1 Trump turbine.
1 Pelton water-wheel.
1 Rife hydraulic ram.

FIG. 1.—THE FRITZ ENGINEERING LABORATORY.

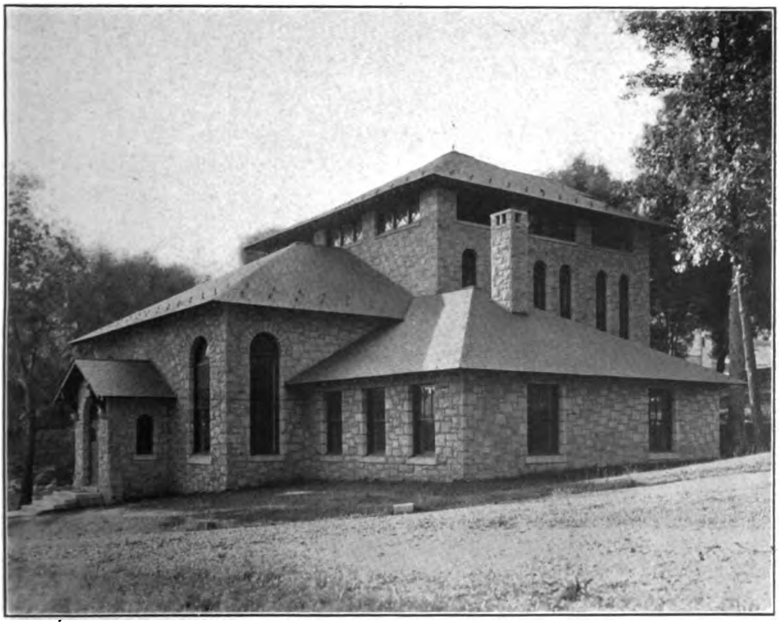


FIG. 6.—THE COXE MINING LABORATORY.

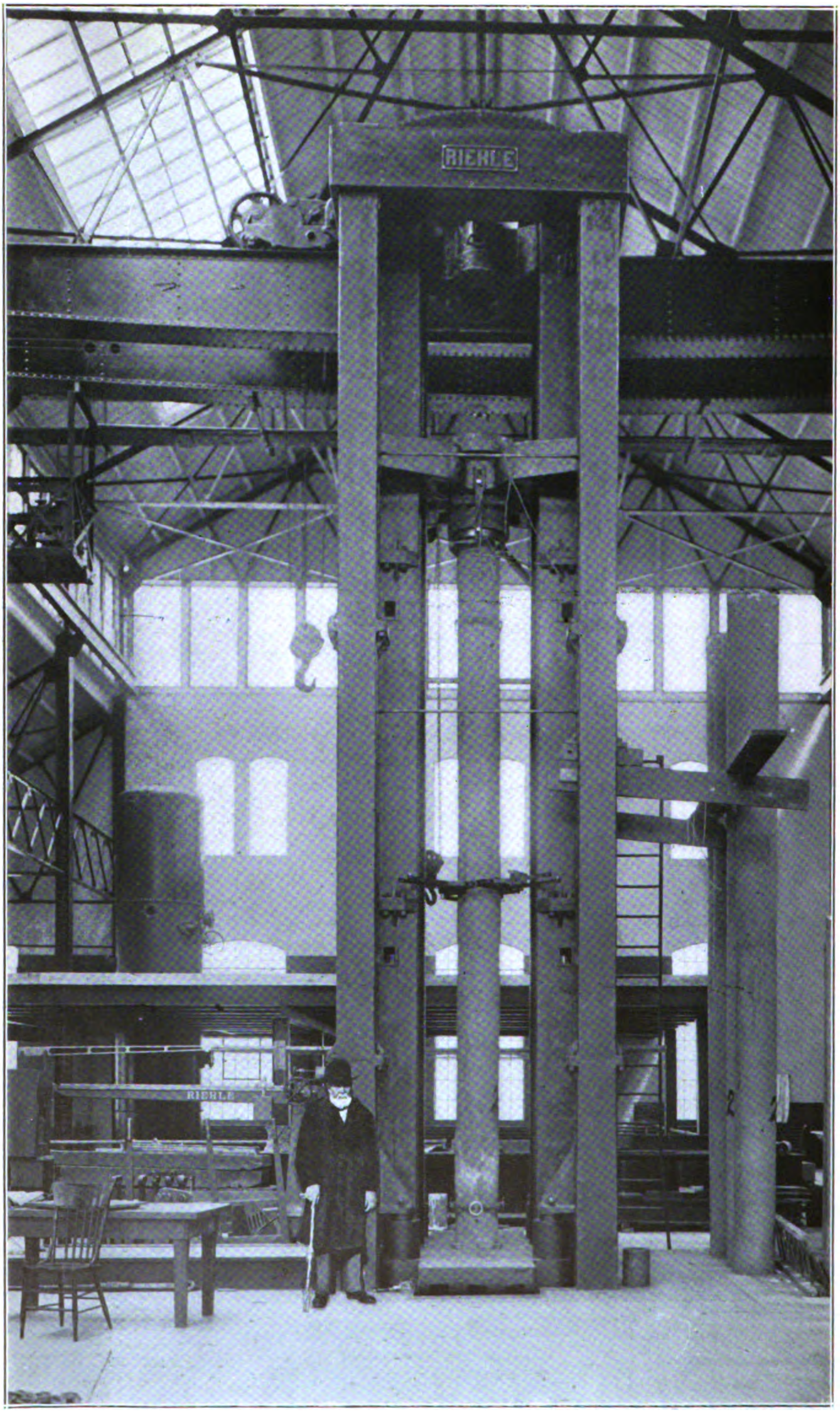


FIG. 4.—100,000-LB. RIEHLÉ TESTING-MACHINE, THE FRITZ ENGINEERING LABORATORY.

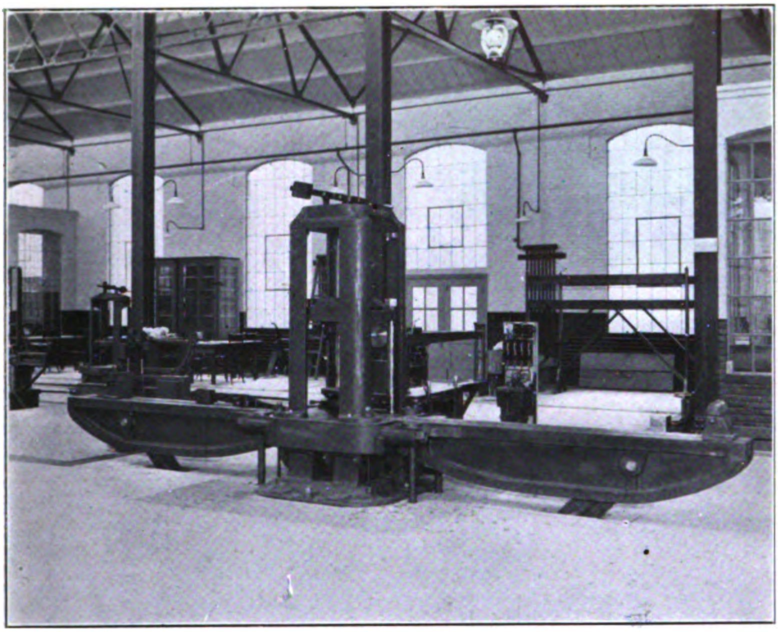


Fig. 5.—300,000-Lb. Olsen Testing-Machine, the Fritz Engineering Laboratory.

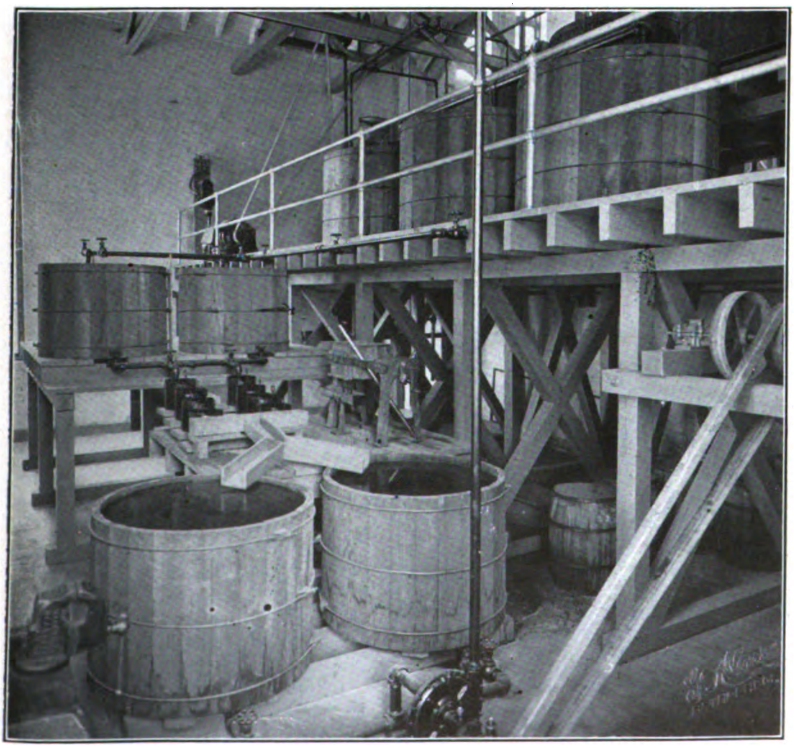


Fig. 7.—Cyanide Equipment, Eckley B. Coxe Mining Laboratory.

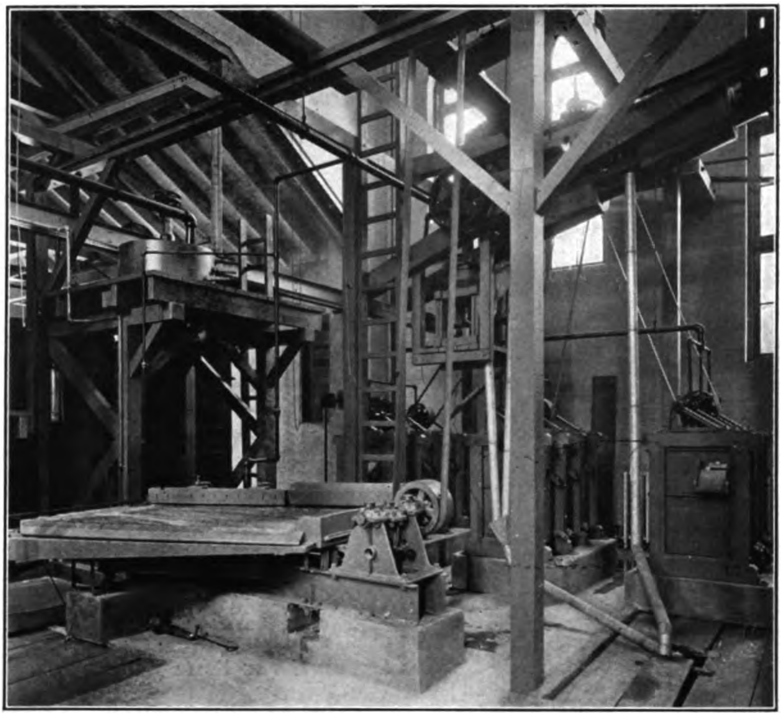


Fig. 10.—Jigs, Trommels, and Overstrom Table, Eckley B. Coke Mining Laboratory.

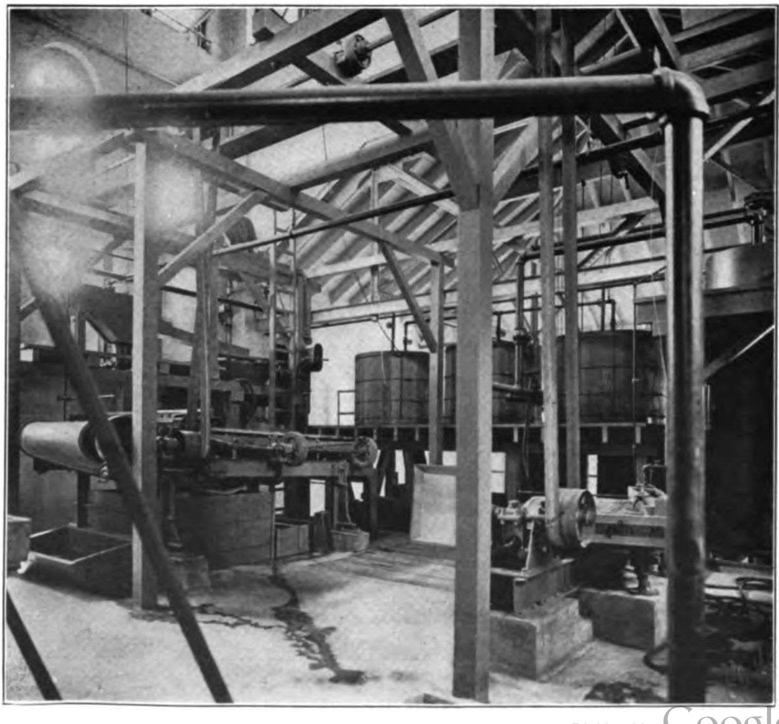


Fig. 11.—Classifiers and Tables, Eckley B. Coxe Mining Laboratory.

In addition, the upper platform carries

1 steel Weir tank—3 by 3 by 18 ft. long.
1 steel tank—6.5 ft. wide, 3 ft. deep, 17.5 ft. long.

This equipment also includes pressure-, mercury-, oil-, and hook-gauges, meters, scales, and so on.

All electricity for lighting and for power for the testing machines and for the pumps is 2-phase, 60-cycle, alternating current at 110 and 220 volts.

The Fritz Laboratory forms part of the equipment of the Department of Civil Engineering, in charge of Prof. F. P. McKibben, to whom I am indebted for most of the preceding data. Instruction in testing and hydraulics is given to students in Civil, Mechanical, Mining, Metallurgical, Chemical, and Electrical Engineering, and Electrometallurgy in the junior year. The equipment is also available for thesis-work in the senior year, and for commercial tests on materials of construction.

II. The Eckley B. Coxe Mining Laboratory.

The Coxe Mining Laboratory is the gift of a friend of Lehigh, and was so named by the trustees in honor of Eckley B. Coxe, at one time an honored President of the American Institute of Mining Engineers, and during his life a devoted friend and trustee of Lehigh University.

Ground was broken for the building in October, 1909, and erection of machinery and equipment was begun in July, 1910. The main part of the equipment was ready for operation in the spring of 1911.

The building, designed by Furness, Evans & Co., of Philadelphia, the architects of Drown Memorial Hall, is of dressed sandstone in broken range style, steel roof-trusses, and finished inside with light Kittanning brick, as shown in Fig. 6. Its principal dimensions are 100 by 75 ft., one story high in front, and two stories high in back in the main part of the laboratory. The main or central part of the building contains the milling laboratory, 40 by 70 ft., built on two floors to secure proper fall for the machines; the two wings, one east and one west, are each 30 by 40 ft. The east wing contains a recitation-room large enough for 40 students, the department office

and library, an instrument-room for mine-surveying outfit; the basement contains a locker- and wash-room. The west wing contains room for a small ore-testing laboratory-equipment, such as screens, classifiers, tables, etc.; a chemical laboratory, and an assaying-room.

The laboratory is well lighted by windows extending the full height of the walls. In the milling laboratory, in the main walls under the eaves, sash-windows, operated from the floor by gearing and chains, furnish ventilation. In the wings, the direct-indirect system of heating and ventilation is employed. Flaming-arc lamps furnish artificial light, and individual lamp-sockets are provided for the various machines. Steam is used for heating and gas for auxiliary purposes.

The water-supply comes from the town mains, and is so arranged that it can be fed to a pressure-tank of 2,000 gal. capacity, or used directly from the mains. Drainage is by pump-pits and open floor-drains, all connected to a system of piping which discharges into a small creek near the building.

The framing and machinery have been painted a uniform light gray color. The concrete floors and pits have been treated with water-proofing paint.

1. *The Milling Laboratory.*

This section occupies the two floors of the main part of the building. The difference in elevation of these floors is 8.5 ft., the two floors being connected by steps and by ladders on the framing. The heavy crushing-machinery, stamp-battery, jigs, tables—all on the upper floor—are erected on substantial concrete foundations which extend nearly to the level of the lower floor. The upper floor, of reinforced concrete, is interrupted by the elevator and pump-pits. The ore-bins, feeding-platforms for the breaker, stamp-battery and grinding-pan, housings for elevators and screens, classifiers and settling-tank supports, and the supports for the motors and shafting, are all of yellow pine, framed construction. Ladders and floor-planks at convenient distances make the entire framework easily accessible.

On the lower floor of the milling laboratory is the cyaniding-department. The tanks, zinc-boxes, filter-press, and the agitation-pump are all carried on framing which extends in lifts up

to the level of the upper floor, thus getting a free fall to the sump-tanks and circulating-pump placed on the lower floor-level, Fig. 7. Typical mill-arrangement and construction, as far as practicable in a mining-school laboratory, have been followed.

The present equipment of the laboratory consists of the following machinery purchased from the Allis-Chalmers Co., and arranged as shown in Figs. 8 and 9:

1 grizzly, 2 by 4 ft.
1 Gates breaker.
2 vertical elevators, 6 in.
1 rolls and wall feeder, 18 by 10 in.
1 set of 3 trommels, 16 by 24 in.
3 3-compartment Harz jigs, 9 by 17 in.
1 Brown conical classifier.
1 Richards 1-spigot classifier.
1 Callow settling-tank, 4 ft.
1 Huntington mill, 3.5 ft.
1 Challenge feeder.
1 3-stamp battery, 500 lb.
1 Frue vanner, 4 ft.
1 Overstrom table, 7 ft.
1 grinding-pan, 36 in.
3 Frenier pumps, 6 by 48 in.
2 centrifugal circulating-pumps, 1.5 in.
1 water-tank, 2,000 gal.
3 solution-tanks, 5 by 4 ft.
3 leaching-tanks, 5 by 4 ft.
2 agitation-tanks, 6.5 by 5 ft.
4 gold- and sump-tanks, 4 by 3 ft.
1 filter-press.
Zinc-boxes, etc.

The machinery mentioned above is supplemented by all necessary fittings, chutes, pipes, trolley-crawls, blocks, and the like.

The electrical equipment consists of five induction-motors, 2-phase, 220-volt, 60-cycle, with auto-starters—giving a total of 50 h-p. Current is obtained from the University Power-Station at 2,200 volts, and is stepped down to 110 and 220 volts for lighting- and power-purposes.

The general plan and equipment was intended to show by actual example the more important types of ore-dressing machinery, and to give a means of demonstrating, by actual runs, the common methods of concentrating and treating the ores of

gold, silver, copper, lead, and zinc, by methods of coarse or fine concentration, amalgamation, or cyaniding. The arrangement of machinery, driven by five separate motors, permits tests to be made on one or a group of machines, or complete tests as a mill-run.

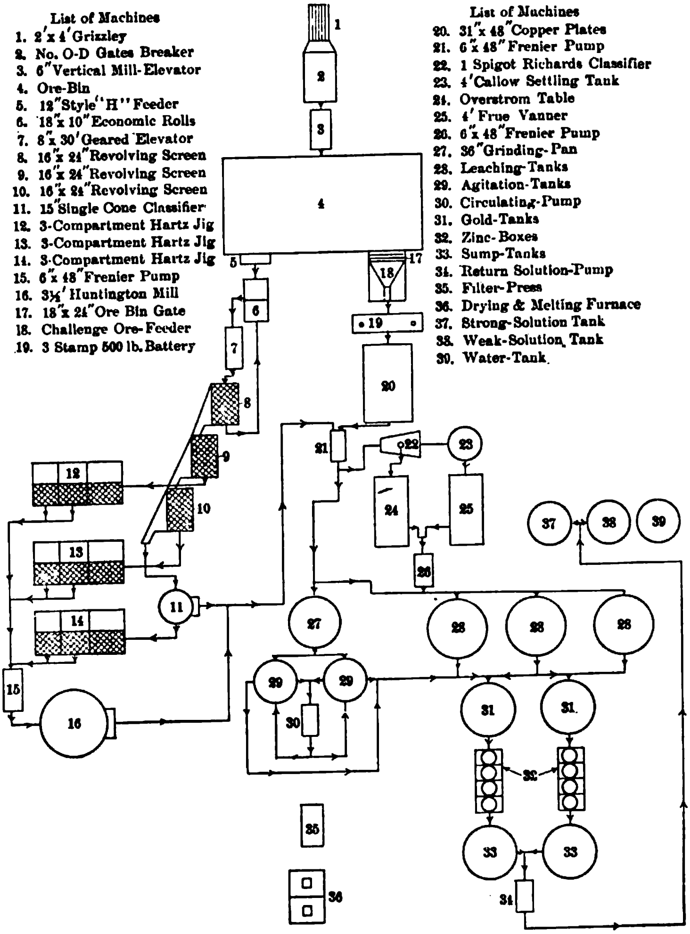


FIG. 8.—ORE-DRESSING EQUIPMENT, ECKLEY B. COXE MINING LABORATORY.

Ore is delivered at the rear end ot the laboratory, where it may be fed direct to an elevator discharging to the bins, or it may be passed over the grizzly, through the Gates breaker, and then to the elevator. The bin is divided into two parts, one for base-metal ores and one for gold-ores.

On the coarse-concentrating side, Fig. 10, the ore is delivered by a wall feeder to the rolls, then to the elevator, and to the trommels and Brown classifier. This material may be jigged, or sent by a Frenier pump to the tables, or delivered to the Huntington mill for further reduction. The three jigs are three-compartment, Harz type. The crushing-machinery, elevators, jigs, and pump are run by a 30-h-p. motor.

The gold-ores are delivered to a Challenge feeder; then fed to the stamp-battery and plates. A 5-h-p. motor. runs the stamp-battery. An amalgam-trap will permit the pulp to pass

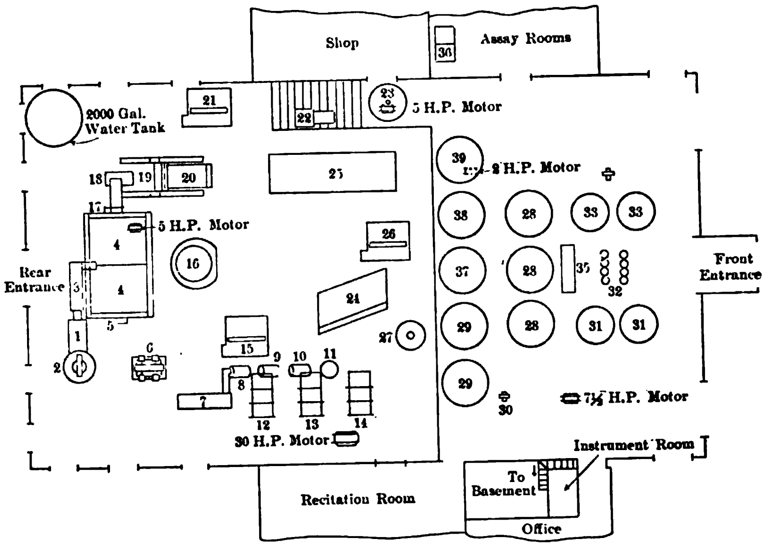


FIG. 9.—FLOOR-PLAN, ECKLEY B. COXE MINING LABORATORY.

to a second Frenier pump, which delivers its material to a Richards classifier and Callow settler. The classified products may be fed to either the Frue vanner, Overstrom table, or both, Fig. 11. Material from these machines is dropped to the third Frenier pump and sent either to the grinding-pan or directly to the agitation- or leaching-tanks. These latter machines are operated by a 5-h-p. motor.

The cyanide-plant consists of three solution-tanks, three leaching-tanks, two agitation tanks connected by a 1.5-in. centrifugal circulating-pump, two gold-tanks, eight zinc-boxes, one filter-press, two sump-tanks, and a second 1.5-in. centri-

fugal pump to return the solution to the upper tanks. A 2-h-p. motor runs this pump; the other, together with the grinding-pan, is run by a 7.5-h-p. motor. The tanks are all of California redwood.

Ore-Testing Laboratory.

This part of the laboratory, not yet equipped, will eventually contain small crushers, rolls, and screens for the reduction and sizing of small batches of ore; laboratory-classifiers of Richards and Munroe types; hand-jigs, and small tables, together with all accessory apparatus.

Assay Laboratory.

This space is divided into three parts, one for fire-assays, one for wet-assays, and one for a balance-room. The instruction in assaying at Lehigh is in charge of the Chemistry Department, hence the room and equipment is intended only to handle the products of the laboratory. The usual outfit for assaying will be found here.

Library, Museum, etc.

The general library of the University contains most of the general books on mining, but in the department-office there is a small reference-library containing most of the books ordinarily required by students, all of the mining journals, and an excellent collection of catalogues, photographs, and blue-prints of mining-machinery.

The department also has a collection of air-drills, coal-cutting machinery, prospecting-drill, tipple-equipment, steel-timbering, mine-lamps, and the like, part of which is housed in the new building.

Scope of Laboratory.

The purpose of the laboratory is to familiarize the students with methods and practice of ore-treatment, and to develop a spirit of investigation and research. Instruction, at the present time, is given to the students of mining and metallurgy during the junior year, and will be extended to include the senior year. Lehigh has commonly been regarded as a coal-mining school; but the present equipment places it among those schools which also emphasize the metal side of the mining industry.

No. 63 MARCH 1912

Bulletin of the American Institute of Mining Engineers.

CONTENTS:

BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

No. 63 MARCH 1912

PUBLISHED MONTHLY
BY THE AMERICAN INSTITUTE OF MINING ENGINEERS
at 124 to 128 N. Seventh St., Philadelphia, Pa.
Guy R. Overend, Publication Manager.

Editorial Office, 29 West 39th St., New York, N. Y.

JOSEPH STRUTHERS, Ph.D., Editor.

Cable address, "Aime," Western Union Telegraph Code.

Subscription (including postage), $10 per annum; to members of the Institute, public libraries, educational institutions and technical societies, $5 per annum.

Single copies (including postage), $1 each; to members of the Institute, public libraries, etc., 50 cents each.

Entered as second class matter, October 16, 1911, at the post office at Philadelphia, Pa., under the Act of March 3, 1879.

TABLE OF CONTENTS.

SECTION I. INSTITUTE ANNOUNCEMENTS.

SECTION II. TECHNICAL PAPERS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

All communications concerning the contents of this Bulletin should be addressed to JOSEPH STRUTHERS, Ph.D., Secretary and Editor, 29 W. 39th St., New York, N. Y.

OFFICERS.

For the year ending February, 1913.

COUNCIL.*

PRESIDENT OF THE COUNCIL.

JAMES F. KEMP..NEW YORK, N. Y.

(Term expires February, 1913.)

VICE-PRESIDENTS OF THE COUNCIL.

S. B. CHRISTY..BERKELEY, CAL.
W. A. LATHROP..PHILADELPHIA, PA.
GARDNER F. WILLIAMS..WASHINGTON, D. C.

(Term expires February, 1913.)

KARL EILERS..NEW YORK, N. Y.
WALDEMAR LINDGREN..WASHINGTON, D. C.
BENJAMIN B. THAYER...NEW YORK, N. Y.

(Term expires February, 1914.)

COUNCILORS.

ROBERT E. JENNINGS...NEW YORK, N. Y.
WILLIAM KELLY..VULCAN, MICH.
CHARLES F. RAND..NEW YORK, N. Y.

(Term expires February, 1913.)

A. E. CARLTON..CRIPPLE CREEK, COLO.
W. J. OLCOTT...DULUTH, MINN.
E. L. YOUNG..NEW YORK, N. Y.

(Term expires February, 1914.)

JOHN H. JANEWAY, JR..NEW YORK, N. Y.
SIDNEY J. JENNINGS...DOBBS FERRY, N. Y.
JOSEPH W. RICHARDS...SOUTH BETHLEHEM, PA.

(Term expires February, 1915.)

SECRETARY OF THE COUNCIL AND EDITOR.

JOSEPH STRUTHERS, 29 W. 39th St......................................NEW YORK, N. Y.

(Term expires February, 1913.)

SECRETARY EMERITUS OF THE COUNCIL.

R. W. RAYMOND..NEW YORK, N. Y.

CORPORATION.

JAMES F. KEMP, President; EDMUND B. KIRBY, Vice-President;
FRANK LYMAN, Treasurer; GEORGE C. STONE, Secretary;
JOSEPH STRUTHERS, Assistant Secretary and Assistant Treasurer.

DIRECTORS.

JAMES GAYLEY, CHARLES KIRCHHOFF, FRANK LYMAN.

(Term expires February, 1913.)

JAMES DOUGLAS, JAMES F. KEMP, ALBERT R. LEDOUX.

(Term expires February, 1914.)

EDMUND B. KIRBY, CHARLES F. RAND, GEORGE C. STONE.

(Term expires February, 1915.)

Consulting Attorneys, Blair & Rudd, New York, N. Y.

* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation.

COMMITTEES.

For the year ending February, 1913.

COUNCIL.

Membership:—Joseph Struthers, Benjamin B. Lawrence, Karl Eilers, Charles F. Rand, Edward L. Young.

Publications:—Joseph Struthers, *Chairman*, New York, N. Y.; David W. Brunton, Denver, Colo.; Samuel B. Christy, Berkeley, Cal.; Albert L. Colby, South Bethlehem, Pa.; Nathaniel H. Emmons, Copperhill, Tenn.; Charles H. Fulton, Rapid City, S. D.; James Gayley, New York, N. Y.; H. O. Hofman, Jamaica Plain, Mass.; Henry M. Howe, Bedford Hills, N. Y.; Walter R. Ingalls, New York, N. Y.; James F. Kemp, New York, N. Y.; R. V. Norris, Wilkes-Barre, Pa.; Edward D. Peters, Dorchester, Mass.; Rossiter W. Raymond, New York, N. Y.; Joseph W. Richards, South Bethlehem, Pa.; Robert H. Richards, Boston, Mass.; Albert Sauveur, Cambridge, Mass.; Henry L. Smyth, Watertown, Mass.; Arthur L. Walker, New York, N. Y.

CORPORATION.

Finance:—Charles F. Rand, James Gayley, George C. Stone.

Library:—James F. Kemp, Charles Kirchhoff, George C. Stone.

Land Fund:—James Douglas, *Chairman*; Theodore Dwight, *Treasurer*; T. F. Cole, Anton Eilers, James Gayley, John Hays Hammond, Charles Kirchhoff, Albert R. Ledoux, Frank Lyman.

INSTITUTE REPRESENTATIVES.

United Engineering Society Trustees:—Joseph Struthers (1913), Theodore Dwight (1914), James F. Kemp (1915).

Joint Conference Committee of the Four National Engineering Societies:—James F. Kemp, Joseph Struthers.

John Fritz Medal Board of Award:—E. Gybbon Spilsbury (1913), R. V. Norris (1914), Charles Kirchhoff (1915), J. F. Kemp (1916).

American Association for the Advancement of Science:—H. O. Hofman, Boston, Mass.; John D. Irving, New Haven, Conn.

Eighth International Congress of Applied Chemistry, New York, September, 1912:—William L. Saunders, New York, N. Y.; George C. Stone, New York, N. Y.

International Association for Testing Materials Congress, Chicago, September, 1912:—Robert Forsyth, Chicago, Ill.

Committee No. 24, International Association for Testing Materials:—Henry D. Hibbard, Plainfield, N. J.

International Engineering Congress, San Francisco, 1915:—Samuel B. Christy, William C. Ralston, Edwin T. Blake.

Academy of Natural Sciences of Philadelphia, Mar. 19, 20 *and* 21, 1912:—John Birkinbine, William A. Lathrop.

INSTITUTE ANNOUNCEMENTS.

Proceedings of the Board of Directors.

The following acts of the Board of Directors of the Institute during the past year are here published for the information of members and associates:

Meeting, Feb. 21, 1911.—The following officers were elected to serve during the ensuing year:

JAMES GAYLEY, *President.*
JAMES DOUGLAS, *Vice-President.*
R. W. RAYMOND, *Secretary.*
FRANK LYMAN, *Treasurer.*

The following Standing Committees were appointed:
Finance: Charles Kirchhoff, Theodore Dwight, Albert R. Ledoux.
Library: R. W. Raymond, James F. Kemp, Charles H. Snow.

The resignation of James Douglas, as representative of the Institute on the John Fritz Medal Board of Award (term expires 1914), was received, accepted, and ordered transmitted to the Secretary of the Board of Award. Mr. R. V. Norris was appointed to fill the vacancy when created.

Mr. Charles Kirchhoff, whose term on the John Fritz Medal Board of Award had just expired, was re-elected to succeed himself (term expires 1915).

The sum of $2,500, or as much thereof as may be needed, was appropriated for library purposes (exclusive of salaries) for the year 1911.

Meeting, Mar. 31, 1911.—The resignation of Dr. Rossiter W. Raymond as Secretary of the Board, member of the Board, and member of the Library Committee, was accepted and Dr. Joseph Struthers was elected to fill the vacancies thus created.

The appointment by the Council of Dr. Raymond as Secretary Emeritus of the Council was confirmed.

In joint action with the Council the following Committee of Fifteen was appointed to prepare an official announcement of the resignation of Dr. Raymond, and the resultant change in the administrative force of the Institute, said announcement to be published in the *Bulletin* for the information of members:

Robert H. Richards, Past President of Council.
E. G. Spilsbury, Past President of Council.
Charles Kirchhoff, { Past President of Council. President of Council, 1911.
James Douglas, Past President of Council.
E. E. Olcott, Past President of Council.
Albert R. Ledoux, Past President of Council.
James Gayley, { Past President of Council. President of Board of Directors.
Robert W. Hunt, Past President of Council.

John Hays Hammond, Past President of Council.
D. W. Brunton, Past President of Council.
Anton Eilers, Past Vice-President of Council.
W. L. Saunders, Past Vice-President of Council.
B. B. Lawrence, Vice-President of Council.
J. W. Richards, Vice-President of Council.
Albert Sauveur, Vice-President of Council.
Frank Lyman, Treasurer, Board of Directors.

Meeting, April 28, 1911.—The report of the Special Committee on Increase of Dues of the Institute, appointed at the Annual Business Meeting of the Institute, Feb. 21, 1911 (Messrs. Joseph W. Richards, E. G. Spilsbury, and Theodore Dwight), was accepted.

The following Special Committee to prepare a proper form of proxy to accompany the recommendation to increase the dues of the Institute was appointed: Messrs. Joseph W. Richards, E. G. Spilsbury, and Theodore Dwight.

The following Special Committee of Nine, to consider and report on the change of name of the Institute to American Institute of Mining and Metallurgy, was appointed: Messrs. James Gayley, A. R. Ledoux, and James F. Kemp, of the Board; Messrs. C. Kirchhoff, B. B. Lawrence and Gardner F. Williams, of the Council; Messrs. R. W. Raymond, W. R. Ingalls, and W. L. Saunders, of the membership at large.

A check for $10,913.30, sent by James Douglas as a contribution to the Land Fund from Phelps, Dodge & Co., was received, and an appropriate letter of thanks was ordered to be sent to Phelps, Dodge & Co. for their munificent gift.

The resignation of Prof. Charles H. Snow as member of the Board, and of the Library Committee, was accepted, and Prof. Arthur L. Walker was elected to fill the vacancies thus created.

Meeting, May 19, 1911.—The report of the Special Committee of Nine recommending the change of name of the Institute to the American Institute of Mining and Metallurgy was approved, and ordered to be printed and distributed to the membership.

On the unanimous recommendation of the Council, Prof. R. H. Richards and Dr. R. W. Raymond were unanimously elected Honorary Members of the Institute.

Mr. George Buckman was appointed Office Manager and Accountant.

The Assistant Treasurer presented a statement of receipts and expenditures of the Institute for the current year to May 1, which was accepted and placed on file.

Meeting, June 16, 1911.—The report of the Special Committee (Messrs. J. W. Richards, E. G. Spilsbury, and Theodore Dwight), appointed Apr. 28, to prepare announcement concerning increase of dues, was accepted.

The Assistant Treasurer presented a memorandum of receipts and expenditures of the Institute for the month of May, which was accepted and placed on file.

Meeting, Aug. 29, 1911 (*Special*).—The reconvening of the adjourned Annual Business Meeting of the Institute was authorized to be called for Sept. 20, 1911.

Meeting, Sept. 20, 1911 (*Adjourned Annual Business Meeting*).—In conformity with the provisions of Article XII. of the Constitution,

written notice was formally presented that certain proposed amendments to the Constitution would be offered for vote at the Annual Meeting, Feb. 20, 1912, as was also the additional amendment presented in person by Mr. E. G. Spilsbury, namely:

"*Nominating Committee:*—A Nominating Committee of five members, not members of the Council, shall be appointed by the President within sixty days after he assumes office. It shall be the duty of the Committee to send to the Secretary on or before November 1, the names of consenting nominees for the elective offices next falling vacant under the Constitution. Upon the request of any member or associate, the Secretary shall furnish to the applicant the names of such nominees."

The Secretary was instructed to print and distribute the above proposed amendment, together with the letter of the Committee explaining the reason for the desired changes, to the entire membership at least thirty days before the next Annual Business Meeting, to be held on the third Tuesday in February in the year 1912. (These proposed amendments were published in circular form and distributed to the entire membership as General Announcement No. 3, Sept. 1, 1911. Also a similar circular containing the same proposals with proxy for vote thereon was mailed to the entire membership under date of Jan. 19, 1912.)

Meeting, Sept. 20, 1911.—The proposed amendments to the constitution, as published in General Announcement No. 3, Sept. 1, 1911, and the proposed amendment by E. G. Spilsbury, individually presented at the adjourned Annual Business Meeting, Sept. 20, 1911, were approved.

The Assistant Treasurer presented a memorandum of receipts and expenditures of the Institute for June, July and August, which was accepted and placed on file.

Meeting, Oct. 20, 1911.—The matter of the proper disposal of the large stock of back volumes of the *Transactions*, and of separate pamphlets of papers, was referred to the Library Committee, with the request to report at a later meeting of the Board.

It was voted to anticipate the adoption of the proposed rule to create a Nominating Committee.

Meeting, Nov. 17, 1911.—The following appointments to the Nominating Committee were reported: Messrs. E. G. Spilsbury, R. V. Norris (later A. S. Dwight), J. R. Finlay, L. D. Huntoon, and C. P. Perin.

The form of circular prepared by the Nominating Committee for distribution to the membership was approved.

The report of the Library Committee recommending special prices for various sets of the *Transactions* (as published in *Bulletins* Nos. 60 and 61, December, 1911, and January, 1912) was approved.

The President of the Council reported that the Post Office authorities had placed the *Bulletin* of the Institute on the Second Class list, which will insure a saving in postage of approximately $1,500 per year. In connection with the action of the Post Office authorities, a special vote of thanks was passed for the friendly co-operation and active interest of Mr. Charles L. Parsons, Secretary of the American Chemical Society.

Meeting, Dec. 15, 1911.—Messrs. E. E. Olcott, and George W. May-

nard were appointed proxies for the vote on the proposed amendments to be acted upon at the Annual Business Meeting, Feb. 20, 1912.

The Assistant Treasurer presented a memorandum of receipts and expenditures of the Institute to Dec. 1, which was accepted and placed on file.

Meeting, Jan. 12, 1912.—The report of the Nominating Committee was accepted and ordered to be sent to every member and associate entitled to vote. Said nominations were:

For President,	JAMES F. KEMP,
For Vice-President,	BENJAMIN B. THAYER,
	KARL EILERS,
	WALDEMAR LINDGREN.
For Councilors,	JOSEPH W. RICHARDS,
	JOHN H. JANEWAY, JR.,
	SIDNEY J. JENNINGS.
For Secretary,	JOSEPH STRUTHERS.

The form of the General Announcement (No. 1 of 1912) concerning the proposed amendments to the Constitution, the form of the proposed amendments, and the form of proxy for vote on the proposed amendments, were accepted and authorized for publication.

The form of proxy for the election of officers, etc., at the Annual Meeting, Feb. 20, 1912, was accepted, and Messrs. Leonard Waldo and Bradley Stoughton were appointed to act as proxies for said election, and for such other business as may come before the Annual Meeting, Feb. 20, 1912, excepting the action on the proposed amendments.

The report of the Treasurer giving an account of the receipts and disbursements for the year 1911, which had been audited by Barrow, Wade, Guthrie & Co., C. P. A., was adopted for presentation at the Annual Business Meeting of the Institute, Feb. 20, 1912.

The Treasurer was authorized to charge off from the Furniture and Fixtures account 10 per cent. per annum for depreciation.

The schedule of salaries for the calendar year 1912 for employees (not including the Library service, which is administered by the United Engineering Society), presented by the Assistant Treasurer, was accepted subject to ratification by the Board of Directors as constituted at the meeting directly following the Annual Business Meeting of the Institute, Feb. 20, 1912.

An appropriation of $1,500 (or as much thereof as may be required) was authorized for Library purposes (not including salaries) for the year 1912.

Prof. James F. Kemp was elected a representative of the Institute on the Board of Trustees of the United Engineering Society to succeed Mr. E. E. Olcott, who retired January, 1912, by limitation.

The report of the Land Fund Committee was presented by Theodore Dwight, Treasurer, showing receipts during the year of $11,273.05, and disbursements of $11,000 on account of principal and mortgage, leaving a balance of $273.05. The original obligation was $288,000, of which the Institute has paid $114,000 of the principal, besides meeting the current interest of 4 per cent. upon the unpaid amount. Outstanding subscriptions to the amount of $6,000 and the cash on hand will reduce the debt to $67,726.95.

Messrs. Charles Kirchhoff and James F. Kemp were appointed a Committee to consider the advisability of increasing the office force and report recommendations at the next meeting of the Board.

Meeting, *Feb.* 9, 1912.—The circular signed by Messrs. Stone, Corning, Ingalls, and others, under date of Feb. 3; also a letter from Waldemar Lindgren, of Washington, concerning the proposed amendments to the Constitution, were presented, and after full deliberation, it was the sense of the meeting to invite the signers of the circular and Mr. Lindgren to appoint a Committee with power to call for any information or documents in the possession of the officers of the Institute at as early a date as possible (and in any event, prior to the Annual Business Meeting).

The Assistant Treasurer presented a report of the receipts and disbursements of the Institute for the month of January, 1912, and the corresponding month of 1911, which was accepted and ordered on file.

The Secretary submitted a brief abstract of the acts of the Board of Directors during the past year, together with a report of the Library Committee, and a brief covering the general meetings of the Institute, publications, and membership. The publication of these reports, for the information of the members, was authorized

JOSEPH STRUTHERS,
Secretary.

Treasurer's Report for the Calendar Year 1911.

The following statement of receipts and expenditures from Jan. 1 to Dec. 31, 1911, was authorized to be published for the information of members and associates by the Board of Directors Jan. 12, 1912.

RECEIPTS.

Balance from statement of January, 1911,		$3,938.17
Annual dues,	$35,619.81	
Life memberships,	1,930.00	
Initiation fees,	1,990.26	
Binding of *Transactions*,	3,271.48	
Sale of publications, electrotypes, advertising, and miscellaneous receipts,	17,368.12	
Interest on bank deposits,	168.23	
		$64,286.07

DISBURSEMENTS.

Printing Vol. XLI. of the *Transactions*, *Bulletin*, extra pamphlets, advertising expenses, etc.,	$15,966.73	
Printing circulars and ballots,	745.18	
Binding Vol. XLI. of the *Transactions*,	3,495.00	
Binding miscellaneous volumes,	137.15	
Engraving and electrotyping,	1,023.31	
Secretary's department, including clerks, stenographers, and expenses of editing and proof-reading, and special assistance in connection with meetings,	10,333.91	
Treasurer's department, including collection of dues, shipping, etc.,	6,881.25	
Library,	2,356.21	
Carried forward,		$40,938.74

Brought forward,	$40,938.74	
Postage,	4,470.91	
Stationery,	483.09	
Express and freight,	1,139.06	
Telephone,	271.90	
Telegrams, cables, carfares, etc.,	121.94	
Office supplies, repairs,	415.53	
Refunding miscellaneous payments,	56.63	
Insurance premiums (fire and surety),	369.12	
Collection charges,	40.51	
Extra clerical assistance,	195.67	
Special stenographers and expenses of meetings,	1,914.38	
Auditing,	115.00	
Sundry expenses,	37.00	
		$50,569.48
Interest at 4 per cent., for 1911, on unpaid balance of land mortgage on 25 to 33 West 39th St. ($85,000, Jan. 1, 1911, reduced to $74,000 April 27, 1911),	3,133.00	
Quota of current expenses of building 25 to 33 West 39th St.,	4,500.00	
		7,633.00
Special editing, new volume of Genesis of Ore-Deposits,	150.00	
Special editing, printing and binding of Index to Vols. XXXVI. to XL.,	775.80	
		925.80
Library additions of books, periodicals, etc., binding of exchanges, and stationery (expenditure from appropriation of $2,500),		811.83
Furniture and fixtures,		114.96
Balance,		4,231.00
		$64,286.07

(Signed) FRANK LYMAN, *Treasurer.*

NEW YORK, N. Y., January 20, 1912.

We have examined the above statement, compared it with the books and vouchers and find same correct.

(Signed) BARROW, WADE, GUTHRIE & Co.,
Certified Public Accountants.

Special Financial Report Concerning the Engineering Societies Building.

Many of the members of the American Institute of Mining Engineers, not resident in the vicinity of New York, in spite of the regular annual reports and the detailed statements which were sent out when the gift of the Engineering Societies Building was received from Mr. Andrew Carnegie, are unfamiliar with the relations between our Institute and the United Engineering Society, in whose name the title stands. It has, therefore, been deemed best by the Council and Directors to submit the following statement:

The title is held by the United Engineering Society as Trustees for our Institute, the Electrical and the Mechanical Engineers each owning one-third. Each Society appoints representatives on this Board of Trustees, and is responsible for one-third of the cost of

the land upon which the building is erected and up to one-third of the running expenses. So much of the building as is not needed for the purposes of the Societies is allotted to other technical or allied organizations, each contributing proportionately to the running expenses. All three Societies have the privilege of admitting to such part of their own floors as they do not for the present require, other societies or institutions not of a business character.

The cost of the building was $1,050,000, given by Mr. Carnegie. The land cost the three Founder Societies $540,000, and has greatly appreciated in value. It is understood that towards the cost of the land, the Electrical Engineers have received gifts covering their entire proportion of the land fund. The Mechanical Engineers, by gifts and by the issuing of certificates of indebtedness, have raised their entire proportion. Generous members of our Institute have subscribed $111,700 in gifts, leaving but $68,000 to be raised by us. There is a mortgage upon the land, bearing interest at 4 per cent. It is necessary that our Institute, if it does not receive further cash gifts, shall arrange to pay off its proportion before the expiration of the mortgage. In the last resort, interest-bearing debentures might be issued, to be paid off by annual sums to be obtained from a surplus in the Institute's regular receipts. If extinguished in ten years, this, with interest at 4 per cent., would call for about $75,000.

It is for this reason, among others, that the Directors and Council approved of the suggestion to increase the dues. The running expenses alone on the present basis could be cared for by the present receipts from dues, etc. The Institute at present is required to pay to the Trustees of the Engineering Society about $4,500 annually towards the cost of maintenance, which is, for office space, very low for the locality and for the space required. The United Engineering Society has to date accumulated from its revenues a fund for depreciation and reserve of $25,000, so that the annual assessment of $4,500 for each Founder Society may be considered the probable maximum. In addition to its regular receipts, the Institute has received from participants in the occupancy of its floor the following sums:

1909	1910	1911
$660	$2,809.33	$1,490.45

The Institute is this year deriving on the present basis an income of $750 from this source.

The net receipts and expenditures of the Institute for 1906 to 1911, inclusive, have been as follows:

	Net Receipts.	Expenditures.
1906,	$51,680.39	$41,127.24 (a)
1907,	55,549.42	55,181.45 (b)
1908,	55,293.27	48,311.44 (b)
1909,	53,750.91	50,023.00 (c)
1910,	51,485.39	49,575.81 (d)
1911,	57,282.18	53,856.35 (e)
	$325,041.56	$298,075.29

NOTE.

(a) Including $2,500 rent at 99 John Street.
(b) Including $4,500 assessment considered as equivalent to rent.
(c) Including $4,500 assessment less $660 released.
(d) Including $4,500 assessment less $2,809.33 released.
(e) Including$4,500 assessment less $1,490.45 released.

In 1907 there was an extraordinary expenditure of $2,625.90 for the large index of our thirty-five volumes of *Transactions* and $3,000 additional for equipment of the new quarters, and moving.

The net receipts, 1906 to 1911, were,	$325,041.56
The ordinary expenditures, 1906 to 1911, were,	298,075.29
Surplus,	$26,966.27

Under the conditions of revenue and outlay, covering a series of six years, the Institute finances showed a book surplus of $26,966.27. The contributions from the Institute to the Engineering Building during this period of 1906 to 1911, inclusive, have been as follows:

Interest payments,		$24,062.99
Total assessments,	$31,700.00	
Less charged for office space,	22,500.00	
Net assessments,		9,200.00
Payment on principal,		15,000.00
		$48,262.99

These drafts upon the Institute have been met in the following manner:

Sale of securities,		$18,708.76
Surplus,		26,966.27
Balance in bank reduced		
From January 1, 1906,	$6,818.96	
To January 1, 1912,	4,231.00	
		2,587.96
		$48,262.99

The total obligations assumed on account of the Engineering Societies Building on the part of the Institute to the end of 1911 have been as follows:

One-third original mortgage,	$180,000.00
Advance payment under founders' agreement,	8,000.00
1906 interest paid from Land Fund,	3,800.00
1907 interest paid from Land Fund,	2,600.00
Interest payments by Institute,	24,062.99
Net assessments,	9,200.00
	$227,662.99

Besides the gifts of $105,700 made to us outright, there is an additional $6,000 which has been pledged, and upon which the donors are paying us interest until they see their way to liquidate the principal.

Proceedings of the Council.

The following acts of the Council of the Institute are here published for the information of members and associates:

Meeting, Feb. 21, 1911.—Messrs. W. L. Saunders and George C. Stone were appointed delegates to represent the Institute at the Eighth International Congress of Applied Chemistry in connection with the sessions to be held in New York in September, 1912.

Meeting, Mar. 31, 1911.—The resignation of Dr. Rossiter W. Raymond as Secretary of the Council and as a member of the Committee on Membership was accepted, and Dr. Joseph Struthers was appointed to fill the vacancies thus created for the unexpired term.

Dr. Raymond was appointed Secretary Emeritus of the Council of the Institute.

The following Committee of Fifteen was appointed to prepare an official announcement of the resignation of Dr. Raymond and the resultant change in the administrative force of the Institute, said announcement to be published in the *Bulletin* for the information of members:

Robert H. Richards, Past President of Council.
E. G. Spilsbury, Past President of Council.
Charles Kirchhoff, { Past President of Council. President of Council, 1911.
James Douglas, Past President of Council.
E. E. Olcott, Past President of Council.
Albert R. Ledoux, Past President of Council.
James Gayley, { Past President of Council. President of Board of Directors.
Robert W. Hunt, Past President of Council.
John Hays Hammond, Past President of Council.
D. W. Brunton, Past President of Council.
Anton Eilers, Past Vice-President of Council.
W. L. Saunders, Past Vice-President of Council.
B. B. Lawrence, Vice-President of Council.
J. W. Richards, Vice-President of Council.
Albert Sauveur. Vice-President of Council.
Frank Lyman, Treasurer of Board of Directors.

Meeting, April 28, 1912.—The following Special Committee was appointed to consider the question of establishing Local Sections of the Institute: Charles F. Rand, E. G. Spilsbury, A. L. Walker, Joseph W. Richards, and Karl Eilers.

The following Special Committee was appointed to consider the establishment of a Committee on Publications: Joseph W. Richards, A. Sauveur, and S. B. Christy.

Meeting, May 19, 1912.—Prof. Robert H. Richards and Dr. Rossiter W. Raymond were unanimously recommended to the Board of Directors for election to Honorary Membership.

Prof. John D. Irving was appointed a representative of the Institute to the American Association for the Advancement of Science, to fill the vacancy caused by the death of Dr. S. F. Emmons.

The report of the Committee on Local Sections was approved and ordered to be printed, and sent to the membership of the Institute.

Permission was granted for the establishment of Local Sections of the Institute at San Francisco and at New York, under the approved regulations

Meeting, June 16, 1911.—A Committee of Five (Messrs. Charles Kirchhoff, Joseph Struthers, James F. Kemp, Charles F. Rand, and Frank Lyman), was appointed to confer with a similar Committee from the Mining and Metallurgical Society of America, with a view to ascertaining the possibility of consolidation of the two societies.

The Regulations for the Committee on Publications, as presented by the Special Committee, Joseph W. Richards, *Chairman*, was accepted (printed in *Bulletin* No. 58, September, 1911).

Meeting, Sept. 20, 1911.—The report of the Special Committee of Five appointed to confer with a similar Committee from the Mining and Metallurgical Society of America, stated that two joint conferences had been held, and after a detailed discussion of the views and work of the A. I. M. E., and the M. & M. S. of A., and the position taken by the latter that its identity and organization must be continued, it was resolved that for the present the proposed affiliation of the Institute and the Society be carried out to the extent of having joint meetings, both of Local Sections and of the parent bodies. This report was approved and accepted.

Permission was granted for the establishment of a Local Section in Boston under the approved regulations.

The following Committee on Publication was appointed:

The Secretary-Editor of the Institute, *Chairman;* David W. Brunton, Samuel B. Christy, Albert L. Colby, Nathaniel H. Emmons, Charles H. Fulton, James Gayley, H. O. Hofman, Henry M. Howe, Walter R. Ingalls, James F. Kemp, R. V. Norris, Edward D. Peters, Rossiter W. Raymond, Joseph W. Richards, Robert H. Richards, Albert Sauveur, Henry L. Smyth, and Arther L. Walker.

The following delegates or representatives were appointed: William J. Chalmers and Robert N. Dickman, to the American Mining Congress, Chicago, Oct. 24–28, 1911.

H. V. Winchell, Installation of George E. Vincent as President of the University of Minnesota, Minneapolis, Oct. 18, 1911.

J. W. Malcolmson, E. E. Howard, P. E. McMullen, and P. N. Moore, to the Third National Conservation Congress, Kansas City, Sept. 25–17, 1911.

Capt. Robert W. Hunt (twice Past President of the Council) was appointed the official representative of the Institute for the San Francisco meeting, and the excursion to Japan.

Meeting, Oct. 20, 1911.—The application for the establishment of a Local Section of the Institute in Spokane, Wash., was granted under the approved regulations.

Meeting, Dec. 15, 1911.—Applications for enrollment as Affiliated Student Societies were granted to the Scientific Society of the Colorado College of Mines, and the Pick and Shovel Club of the Case School of Applied Science.

Robert W. Forsyth was appointed to represent the Institute at the meeting of the International Association for Testing Materials, September, 1912.

Prof. James F. Kemp was elected a member of the John Fritz Medal Board of Award for the period Jan. 1, 1912, to Jan. 1, 1916.

Messrs. Charles Kirchhoff and Joseph Struthers, as President and

Secretary of the Council, were appointed representatives of the Institute on the Joint Conference Committee of the Four National Engineering Societies.

Meeting, Jan. 12, 1912.—The By-Laws of the Spokane Local Section of the Institute were approved.

Mr. Charles Kirchhoff was elected to represent the Institute at the 1912 Congress on Accident Prevention of the Congrès Technique International, at Milan, Italy.

Messrs. Samuel B. Christy, William C. Ralston, and Edwin T. Blake were appointed delegates to represent the Institute at the International Engineering Congress, San Francisco, 1915.

The following honorary delegates were appointed to represent the Institute at the annual meeting of the Canadian Mining Institute, Toronto, March 6, 7 and 8, 1912: Messrs. John Birkinbine, H. M. Chance, C. R. Corning, James Douglas, Theodore Dwight, W. E. C. Eustis, J. R. Finlay, F. Lynwood Garrison, Walter R. Ingalls, William Kelly, James F. Kemp, Benjamin B. Lawrence, Albert R. Ledoux, Ambrose Monell, Henry S. Munroe, R. V. Norris, Edward W. Parker, Robert H. Richards, E. Gybbon Spilsbury, H. H. Stoek, Joseph Struthers.

Institute Activities.

Meetings of the Institute.

There were held during the year 1911 two meeting of the Institute for the presentation and discussion of technical papers—the 100th meeting, at Wilkes-Barre, Pa., June 6–10, and the 101st meeting, at San Francisco, Cal., October 10–17.

A detailed record of the proceedings of these meetings, including a description of the entertainments and excursions connected therewith, has been published and duly distributed to the membership—the Wilkes-Barre meeting in *Bulletin* No. 55, July, 1911, pages 575 to 594; the San Francisco meeting in *Bulletin* No. 59, November, 1911, pages v. to xxxviii.; and the excursion to Hawaii and Japan in *Bulletin* No. 61, January, 1912, pages 1 to 102.

At the Wilkes-Barre meeting there were recorded 38 papers, 7 discussions, and an attendance of 188 members and guests registered at the local headquarters. This number is much less than the total number attending the sessions and participating in the excursions, due to the impossibility of getting every one to register. Special mention should be made of the group of excellent papers on anthracite practice which were presented at the technical sessions.

At the San Francisco meeting there were recorded 39 papers, 2 discussions and a registered attendance (doubtless incomplete) of 214 persons. Prior to the meeting there was a special train-trip of 70 members and guests of the Institute, which started from Chicago, Sept. 30, 1911, visiting the Grand Canyon of the Colorado, in Arizona, Los Angeles, Santa Barbara, and Del Monte, and arriving at San Francisco on Oct. 10, 1911.

Subsequent to the meeting there was an excursion to Hawii and Japan, in which 82 members and guests participated. This party

left San Francisco on Oct. 17 on the steamer *Manchuria;* was delightfully entertained in Japan for 18 days, and returned via steamer *Siberia*, which arrived at San Francisco, Dec. 7, 1911.

Local Sections.

During the year, local sections have been formed at New York, Spokane, and Boston, and meetings have been held as recorded in the *Bulletin*. The members and associates in San Francisco, Los Angeles, and at other places also, have under consideration the extension of this important activity of the Institute.

Affiliated Student Societies.

Ten organizations of undergraduates at technical schools and universities were recognized as Affiliated Student Societies during the year 1911. The total number of Societies enrolled is 21, representing the following institutions: Yale University—Sheffield Scientific School, University of Illinois, University of Nevada, University of Wisconsin, Lehigh University, University of Minnesota, Massachusetts Institute of Technology, University of Kansas, University of Idaho, State College of Washington, University of Texas, Ohio State University, Stanford University, Columbia University, University of California, Tufts College, University of Washington, Iowa State College, Missouri School of Mines, Case School of Applied Science, Colorado School of Mines.

Publications.

Transactions.—Vol. XLI. of the *Transactions*, an octavo of 1004 pages, comprising 55 papers and 10 discussions presented during the year 1910, was issued and distributed to the membership in June.

Vol. XLII. is in process of completion, more than half the work being finished. It is now in the hands of the printer, and it is expected that the bound volume will be ready for distribution in June, 1912.

Special Posepny Volume.—This volume, to be known as the Emmons Volume, will supplement the former Posepny volume, and comprises important papers on geology which have appeared in the *Transactions* subsequent to the publication of the former volume. The manuscript for this work is nearly completed, and about half of the volume is in type.

Bulletin.—Twelve numbers of the *Bulletin* (Nos. 49 to 60), containing the technical papers and discussions of the Institute (in "subject to revision" form) and announcements of general interest to the members of the Institute, such as Library accessions and requirements during the year 1911, notices of meetings of the Institute and other societies, lists of proposed members and associates, changes of addresses, deaths of members, obituary notices, etc., have been published and distributed promptly throughout the year 1911. The number of pages occupied by technical papers and discussions amounts to 1042, to which are to be added 400 pages of announcements, and 360 pages of advertising matter, making a total of 1802 pages of printed matter.

The editorial and business management of the *Bulletin*, Volume XLI., and the forthcoming Volume XLII. of the *Transactions* continues in charge of Dr. Joseph Struthers, Secretary and Editor of the Institute.

Membership.

Changes in the membership of the Institute have taken place during the calendar year 1911 as follows:

Two Honorary members, 184 members, and 13 associates have been elected; 14 members have been reinstated, and 3 associates have become members; a total of 216. Against this number should be recorded the deaths of 48 members and 3 associates; the resignation of 94 members and 9 associates; and the dropping from the roll, by reason of non-payment of dues, of 93 members and 5 associates—a total of 252, which shows a net loss in membership of 36. The net loss in membership in 1910 was 74. The total membership on Jan. 1, 1912, was 4,174.

The list of deaths reported during the year 1911 comprises the following names, the figures in parentheses indicating the year in which the persons named were elected to membership:

Members and Associates: William Affleck (1906), Rupert C. Alabaster (1905), Louis R. Alberger (1899), Sidney M. Bamberger (1903), Roswell E. Briggs (1901), Paul K. Brill (1908), Alexander E. Brown (1875), Henry W. Bulkley (1879), Pierre Choteau (1876), Francis Collingwood (1882), Robert P. Cosby (1903), Milton T. Culbert (1906), John C. Dods (1881), James A. Diggles (1897) Samuel F. Emmons (1877), Horace H. Emrich (1903), Robert Forrester (1902), Percy Grave (1898), Julius Grillo (1896), Charles B. Grubb (1887), Conrad E. Hesse (1890), Edwin M. Holmes (1903), Epenetus Howe (1886), Charles J. Hughes (1895), Charles Wallace Hunt (1891), Henry Janin (1872), J. E. Johnson (1880), Washington Jones (1881), Henry M. Kurtz (1893), H. L. Lawrence (1893), J. Henry Lee (1890), N. W. Lord (1875), Edward K. McCan (1903), James A. McClurg (1898), Edward P. Martin (1881), Charles A. Matcham (1897), Alfred T. Metcalf (1891), Charles H. Morgan (1874), Thomas D. Murphy (1896), John O. Norbom (1909), A. Lanfear Norrie (1890), Francis L. Potts (1882), Ellen H. Richards (1879), Charles H. Shelby (1909), Ernest Sticht (1885), W. J. Sutherland (1899), Archibald A. Swan (1904), Heber S. Thompson (1876), M. D. Valentine (1876), Robert A. Weiss (1908), Howard Wood (1888).

Library Committee.

The following is the Report of the Library Committee for the year ending Feb. 20, 1912. R. W. Raymond, *Chairman*, James F. Kemp, and Charles H. Snow were appointed Feb. 21, 1911. Dr. Raymond resigned from this Committee on Mar. 31, 1911, and was succeeded by Dr. Joseph Struthers. Professor Snow resigned April 28, 1911, and was succeeded by Prof. A. L. Walker.

The general management of the Library administration was discussed informally during the year, special attention being given to the disposal of the back volumes of the *Transactions*, of which there is a large stock on hand.

The Library Committee presented to the Board at the meeting of Nov. 17, 1911, the following schedule of reduced prices for various sets of volumes of the *Transactions*, which was duly approved by the Board:

		Per Set.
I.	200 sets of 5 volumes, bound, from No. 36 (1906) to No. 40 (1910)	$20.00
II.	75 sets of 10 volumes, bound, from No. 31 (1902) to No. 40 (1910) Including the Mexican Volume,	$35.00
III.	50 sets of 20 volumes, bound, from No. 21 (1893) to No. 40 (1910)	$50.00
IV.	25 sets of 30 volumes, bound, from No. 11 (1883) to No. 40 (1910)	$60.00
V.	50 sets of 39 volumes, bound, from No. 1 (1873) to No. 40 (1910) with the exception of No. 10 (1882)	$75.00
VI.	50 sets of 9 volumes, bound, from No. 1 (1873) to No. 9 (1881)	$25.00

This Committee has still under consideration the disposal of the large stock of pamphlet reprints of the papers of the *Transactions*.

Committee on Membership.

The following is the report of the Committee on Membership for the year ending Feb. 20, 1912. Dr. R. W. Raymond, *Chairman*, Benjamin B. Lawrence, Karl Eilers, Charles F. Rand and Edward L. Young were appointed on the Committee on Membership, Feb. 21, 1911. Dr. Raymond resigned from the Committee on Mar. 31, 1911, and Dr. Joseph Struthers was elected to fill the vacancy for the unexpired term.

During the past year, the Committee met monthly, except in July and August, acted upon 224 cases, and made the following recommendations to the Council: for election as member, 194; for election as associate, 20; for change of status from associate to member, 7.

In addition to routine business relating to the professional and educational qualifications of candidates, which were in every case carefully and earnestly studied, the Committee has considered the question of ways and means of increasing the membership of the Institute, the strengthening of the requirements for admission to the class of members, the form of proposal blank for candidates, and other allied matters.

Annual Business Meeting.

The annual business meeting of the Institute was held Feb. 20, 1912, at 10 a.m., at the Institute headquarters, 29 West 39th Street, New York.

A large attendance was present. The meeting was called to order by Dr. James Douglas, Vice-President of the corporation, who presided.

After the reading and approval of the minutes of the Annual Busi-

ness Meeting held Feb. 21, 1911, and of the adjourned meeting held Sept. 20, 1911, Dr. Douglas stated that in view of the desirability of harmonizing divergent opinions as to the advisability of adopting the proposed amendments to the Constitution, he would suggest that the regular order of business be temporarily suspended, and that a motion be considered at this point in the proceedings relating to the appointment of a Committee. A motion to that effect was unanimously carried.

Mr. J. Parke Channing submitted a resolution to the effect: That action upon the proposed amendments to the Constitution, which have been circulated among the members, be deferred to an adjourned session of this meeting, to be held June 3, 1912, or on such date thereafter as may be mutually agreed upon between the Committee and the Directors of the Institute, due notice of the date to be sent to all members and associates of the Institute.

That Messrs. James F. Kemp, C. R. Corning, George C. Stone, W. H. Nichols, Jr., and A. R. Ledoux, be appointed a Committee of five, with power to fill vacancies among their number, to investigate all of the affairs and operations of the Institute, to see whether an increase in dues cannot be avoided, and to report to the Board of Directors by May 1, 1912, making such suggestions as they may deem best for the welfare of the Institute, and that said Board of Directors shall cause such report to be printed and distributed at once by mail to each member, so that it may be considered and acted upon at an adjournment of this meeting. Also, that this Committee be directed and empowered to engage, at the expense of the Institute, independent clerical and auditing assistants.

This resolution, having been duly seconded, was put to vote and unanimously adopted.

Dr. Douglas was called away from the meeting and Dr. Albert R. Ledoux, at the request of those present, took the chair in his stead.

The following officers were elected:

COUNCIL.

President of the Council.

James F. Kemp, ... New York, N. Y.
(Term expires February, 1913.)

Vice-Presidents of the Council.

Karl Eilers, ... New York, N. Y.
W. Lindgren, ... Washington, D. C.
Benjamin B. Thayer, ... New York, N. Y.
(Term expires February, 1914.)

Secretary of the Council.

Joseph Struthers, ... New York, N. Y.
(Term expires February, 1913.)

Councilors.

John H. Janeway, Jr., ... New York, N. Y.
Sidney J. Jennings, ... New York, N. Y.
Joseph W. Richards, ... So. Bethlehem, Pa.
(Term expires February, 1915.)

Directors.

E. B. Kirby, ... St. Louis, Mo.
Charles F. Rand, ... New York, N. Y.
George C. Stone, ... New York, N. Y.
(Term expires February, 1915.)

[SECRETARY'S NOTE.—The complete list of all officers of the Institute will be found on p. ii. of this number of the *Bulletin*. The following explanation, first published in *Bi-Monthly Bulletin*, No. 8, March, 1906, p. viii., is here repeated in order to recall to old members, and convey to new ones, the relations of the two governing bodies as determined by the Certificate of Incorporation of the Institute, and the Constitution and By-Laws adopted in accordance therewith.

The body legally responsible for the business management is the Board of nine Directors (three elected annually to serve three years), which elects its own officers. This body, for reasons of practical convenience, is composed of well-known members residing in New York City, and able to attend, without serious inconvenience or expense, the necessary meetings of the Board. The officers of this Board are legally the officers of the Institute. But, apart from business management, the Board exercises no control over the election of members, or the professional and technical work of the Institute, except that its vote is required to elect honorary members, upon the recommendation of the Council.

The Council is a body constituted in all respects (except that it has no Treasurer) like the Council existing before the incorporation of the Institute, in January, 1905, and charged with all duties and powers, except those which the Board of Directors must legally perform. It elects members, appoints the times and places of professional meetings, and controls the publication and distribution of papers and volumes, etc. Its members (President, Vice-Presidents and Councilors) are elected by the members of the Institute, voting in person or by proxy, and after publication of the nominations received; and it is intended to represent, as far as practicable, both the professional and the geographical distribution of the membership. Consequently, whatever professional honor attaches to official position belongs to membership in the Council, rather than in the legal Board of Directors. This remark implies no disparagement of the members of the latter body, every one of whom has served, or is now serving, as a member of the Council. But it is only fair to explain that their election and continued reelection as Directors is simply a matter of legal convenience.]

Dr. Ledoux, towards the close of the meeting, made the following address:

The Chair ventures to congratulate all of those who are present, and those who are far away, but are represented here by proxy, on the result of this "electricity" which has been in the air and has been felt by all, which has ended in such unity of action—there has been no rivalry among the candidates for officers or councilors, and I am very sure that as far as I represent the management of the Institute —being a Director—that I voice the sentiment of all of them, all of the Directors, and I am sure I voice the sentiment also of all the Councilors, in stating that we are very much gratified that so much interest has been taken in the annual meeting this year, especially by the presence of this very large number of members attending our meeting, which indicates that greater activity may be expected in the future from all the membership, starting from the time of this meeting. I believe we had present some twelve members at our Annual Meeting last year, as recorded in the minutes, against some 140 odd members present here to-day.

We shall go forward feeling quite confident that this Committee which has been appointed to look into the affairs of the Institute will learn a great many things which some of them do not now know, and they will be able to give very useful advice, no doubt, in regard to some matters which possibly have gotten somewhat into a rut, or into a system of routine, and I feel quite confident—and I emphasize that confidence, because I do not feel that I will be able to serve on the Committee—I feel quite confident that the result of the deliberations of this Special Committee which has been appointed, whose report is to be presented to the next meeting, or the adjourned meeting, will be one of very great interest, and we may look forward to still greater activity and increase of membership, and a greater amount of useful work done by our members, with correspondingly greater benefits to be received from our gatherings.

Proxies for Vote on Proposed Amendments to the Constitution of the Institute.

For the information of members and associates who gave proxies to vote on the proposed amendments to the Constitution, it is here

published that at the annual business meeting of the Institute, held Feb. 20, 1912, it was voted to defer action on said amendments until an adjourned business meeting, called for June 3, 1912, prior to which time the report of the Special Committee, Messrs. C. R. Corning, James F. Kemp, Albert R. Ledoux, George C. Stone, and William H. Nichols, Jr., appointed to study the affairs of the Institute, will be published and sent to the membership at large. This gives time for full discussion and consideration of that which will conduce to the best interest of the Institute.

United Engineering Society.

Treasurer's Report for the Year 1911.

The following is the report of the Treasurer of the United Engineering Society for the year 1911:

United Engineering Society.

29 WEST 39TH STREET, NEW YORK,
January 23, 1912.

TO THE BOARD OF TRUSTEES,
United Engineering Society.

I beg to submit herewith the report of your Treasurer as of Dec. 31, 1911.

I. *Finances.*

As shown by the balance sheet submitted herewith, the physical property of the United Engineering Society, over and above the value of the building and the equity in the land, consists of building equipment amounting in value to $25,037.72, furniture and fixtures $5,368.45, and library books $280.62.

During the year 1911 there was added to the Furniture and Fixtures Account an amount representing an expenditure of $1,429.06, including lens for camera in library, telephone booth, two typewriting machines for librarian, office furniture for library, canopy and miscellaneous items, and books for the library amounting to $75.46.

The principal of the mortgage on the land held by Andrew Carnegie, Esq., amounting originally to $540,000, has been reduced by payments from the Land and Building Funds of the Founder Societies to $128,000—the American Society of Mechanical Engineers has made further payments during the year of $81,000, bringing its total payments to $180,000, the full amount of its proportion of mortgage. The American Institute of Mining Engineers has made a further payment of $11,000, reducing the balance due from it to $74,000. The American Institute of Electrical Engineers' balance of mortgage amounts to $54,000.

The gross operating expenses for the year 1911 were $38,279.35, an increase over the year 1910 of $3,773.10, mainly due to an augmented pay-roll.

In accordance with a resolution of the Board at the meeting held

on Jan. 26, 1911, an appropriation of $5,000 was made out of the surplus for the year 1910, and of this amount $4,933.75 was invested in the Delaware & Hudson Company 4 per cent. bonds as an addition to the Contingency and Renewal Fund, as provided for in the Founders' Agreement, bringing the invested amount of the Reserve Fund up to $20,265. It is recommended that a similar appropriation be made out of the available balance from this year's operations, which will then show a balance to be added to Surplus Account of $9,979.75.

The assessments paid for the year 1911 by the Founder Societies, each occupying one entire floor, were $4,500 each, representing a total expenditure by each, including interest on its full principal of mortgage on land, of $11,700, reduced in each case to the extent the Society may have paid off part of its mortgage share. As the Associate Societies are assessed approximately $10,000 for equivalent facilities, it will be seen that the Founder Societies are still carrying more than their proportion of the carrying-charges for equivalent office space occupancy in the building.

II. *Building.*

Equipment.—During the year 1911 the Real Estate Equipment Account has been increased to an extent of $8,270, chiefly due to the expense of $6,196, incurred in installing the mezzanine balcony in the main library (authorized by the Board, April 27, 1911). This increased equipment is fully recognized as a useful and æsthetic addition.

There was also installed on the passenger elevators the much-needed hotel annunciator signal-system, at a cost of $1,500. The wisdom of this installation is reflected in the reduction of the cost of elevator service from $5.81 per day in 1910 to $4.30 per day in 1911—a saving of $1.51 per day.

Office Occupancy.—Attention is called to the fact that on Jan. 1, 1912, there was no unoccupied floor space devoted to office use in the building, but that there were three rooms vacant on the 12th floor (former occupancy value of $2,000), originally designed for a museum, but first used as a storage by the Founder Societies, and later for occupancy as a lecture-room by the Columbia University Extension Course in Architecture. These rooms have been vacant since July 1, 1911, but have been temporarily used by the library staff during the installation of the mezzanine gallery and alterations in the main room of the library.

Meetings or Lectures.—The record of the number of times the rooms were used during 1911 for meetings or lectures (not for office occupancy) is:

Meeting Room.	Number of Times Occupied. 1910.	1911.	Change.
Auditorium, 3d and 4th floors,	36	44	8 more.
No. 1 Assembly-Room, 5th floor,	25	40	15 more.
No. 2 Assembly-Room, 5th floor,	53	54	1 more.
Lecture-Room No. 5, 6th floor,	39	34	5 less.
Lecture-Room No. 6, 6th floor,	21	7	14 less.
Lecture-Room No. 7, 6th floor,	1	0	1 less.
Lecture-Room No. 8, 6th floor,	63	86	23 more.
Small Committee-Room, 2d floor,	38	26	12 less.

During the year 1911 the facilities of the building were enjoyed by 48 societies holding a total of 251 meetings, with an attendance of 42,400, as contrasted with the same number of meetings—251—during 1910, with an attendance of 30,722, a gain in attendance for 1911 of 11,678.

Beginning May 1, 1911, lecture-room No. 6 was withdrawn from use as a lecture-room and utilized for office occupancy.

III. *Library.*

During the year 1911 there were added to the Library of the three Founder Societies and the United Engineering Society 2,590 volumes and pamphlets, making a total of 47,500 volumes and pamphlets in the library.

The increase in attendance is particularly gratifying, being 11,014 in 1911 as compared with 9,320 in 1910—an increase of more than 18 per cent.

The new department of research-work is being developed as rapidly as the size of present force will permit. One hundred and forty-three searches were made, and copies of the references preserved for general use. The requests for researches have been largely by correspondence from Japan, South Africa, Australia, Canada, England, and different parts of the United States. The Library receives more than 700 technical periodicals, which are available for this special reference-work.

The construction of the mezzanine gallery, authorized by the Board of Trustees of the United Engineering Society, April 27, 1911, has increased the capacity of the shelves about 10,000 volumes, and has added materially to the architectural appearance of the room.

Respectfully submitted,
JOSEPH STRUTHERS, *Treasurer.*

FINANCIAL REPORT.

Balance Sheet, January 1, 1912.

ASSETS.

Real estate, land,		$540,000.00
Real estate, building,		1,050,000.00
Real estate, equipment,		25,037.72
Furniture and fixtures,		5,368.45
New York City bonds (cost) reserve,		5,231.25
New York City bonds (cost) reserve,		5,062.50
Baltimore & Ohio bonds (cost) reserve,		5,037.50
The Delaware & Hudson Co bonds (cost) reserve,		4,933.75
Library books, United Engineering Society,		280.62
Library adjustment accounts,		169.33
Accounts receivable,		7,456.82
Unexpired insurance,		2,044.04
Cash:		
Working balance,	$5,143.37	
For reserve fund,	5,000.00	
Ways and Means Committee,	1,165.08	
		11,308 45
Petty cash,		500.00
		$1,662,430.43

LIABILITIES.

Balance of land mortgage A. I. E. E.,	$54,000.00	
Balance of land mortgage A. I. M. E.,	74,000.00	
		$128,000.00
A. I. E. E. equity in building,		350,000.00
A. S. M. E. equity in building,		350,000.00
A. I. M. E. equity in building,		350,000.00
A. I. E. E. equity in real estate equipment,		3,346.61
A. S. M. E. equity in real estate equipment,		3,346.62
A. I. M. E. equity in real estate equipment,		3,346.62
A. I. E. E. payments to date in liquidation of mortgage on land,		126,000.00
A. S. M. E. payments to date in liquidation of mortgage on land,		180,000.00
A. I. M. E. payments to date in liquidation of mortgage on land,		106,000.00
Depreciation and reserve fund,		25,000.00
Ways and Means Committee,		1,165.08
Library adjustment accounts,		139.33
Accounts payable,		1,805.51
Surplus account,		34,280.66
		$1,662,430.43

Statement of Receipts and Disbursements, Year Ending December 31, 1911.

CASH RECEIPTS.

Balance on hand, January 1, 1911,	$16,169.30
Account of reduction of mortgage on land,	92,000.00
Account of interest on mortgage,	7,839.57
Assessment of Founder Societies,	12,375.00
Assessment of Associate Societies, offices, meetings, etc.,	38,875.52
Library account,	7,625.90
Interest on bonds and deposits,	1,368.04
	$176,253.33

DISBURSEMENTS.

Account of reduction of mortgage on land,	$92,000.00
Account of interest on mortgage,	7,839.57
Account of real estate equipment,	8,270.00
Operating expense—cash expenditures,	37,164.39
Furniture and fixtures,	1,195.61
Library account,	7,625.90
Bonds purchased (reserve),	4,933.75
Accrued interest on bonds purchased,	92.78
Accounts payable (from 1910),	1,341.26
A. I. M. E. office space released,	1,490.45
Insurance,	2,075.88
Library adjustment,	839.83
Library books U. E S.	75.46
Balance on hand, January 1, 1912,	11,308.45
	$176,253.33

Operating Income and Expenses, Year Ending December 31, 1911.

INCOME.

Assessment Founder Societies,	$13,500.00	
Less: Refund for office space released,	1,886.45	
		$11,613.55
Assessment Associate Societies,		26,745.93
Assessment miscellaneous (offices and meetings),		8,079.00
Telephone returns,		3,759.95
Miscellaneous charges to societies,		2,125.33
U. E. S. library book returns,		75.46
U. E. S. library returns,		53,99
Interest,		1,275.26
		$53,728.47

EXPENSES.

Operating expenses, gross,	$38,279.35
Reserve fund,	5,000.00
Insurance,	31.84
Depreciation on furniture and fixtures,	437.53
Balance carried to surplus account,	9,979.75
	$53,728,47

(Signed) JOSEPH STRUTHERS,
Treasurer.

Board of Trustees for the Year 1912.

The representatives of the three Founder Societies forming the Board of Trustees for the year 1912 are:

American Society of Mechanical Engineers:
Jesse M. Smith, Alexander C. Humphreys, Fred. J. Miller.
American Institute of Mining Engineers:
Joseph Struthers, Theodore Dwight, James F. Kemp.
American Institute of Electrical Engineers:
Walter S. Rugg, H. H. Barnes, Jr., Gano Dunn.

The officers of the Board of Trustees for the ensuing year are:

President, Alexander C. Humphreys.
First Vice-President, Gano Dunn.
Second Vice-President, James F. Kemp.
Secretary, F. R. Hutton.
Treasurer, Joseph Struthers.
Assistant Treasurer, Theodore Dwight.

The Japan Excursion.

A recent letter from Prof. Tsunashiro Wada, representative of the Japanese Reception Committee, gives the following complete list of names of individuals and companies who participated in the reception of the members and guests of the Institute during the excursion in Japan, November, 1911.

General Reception Committee.

Baron Eiichi Shibusawa, *Chairman.*
Tsunashiro Wada, *Representative.*
Takuma Dan,
Rentaro Hotta,
Reiji Kanda,
Keisuke Kato,
Benzo Katsura,
Rokusaburo Kondo,
Kiugo Nambu,
Kageyoshi Noro,
Masayuki Otagawa,
Wataru Watanabe,
Shigema Yamanouchi.

Local Committee.

Kyoto.—Jisaburo Yokobori, *Representative.*
Viscount Tadashiro Inouye,
Daikichi Saito,
Toshio Watanabe.
Osaka.—Heitaro Fujita, *Representative.*
Kaichiro Imaizumi,
Yoichi Katsura,
Keijiro Nakamura.
Moji.—Takichi Aso, *Representative.*
Kiushu. — Yoshitaro Watanabe, *Representative.*
Susumu Hattori,
Kin-ichiro Katayama,
Sokichi Ko,
Naka Matoba,
Chusuke Suehiro.
Nikko.—Rokusaburo Kondo, *Representative.*

Special Traveling Committee.

Tetsutaro Hasegawa,
Reiji Kanda,
Otohiko Matsukata,
Masayuki Otagawa.
Patrons.—Chikuho Coal Mining Association,
Baron Densaburo Fujita,
Furukawa Mining Co.,
Hokkaido Colliery and Steamship Co.,
Fusanosuke Kuhara,
Mitsu Bishi Co.,
Mitsui Mining Co.,
Viscount Seikyo Naito,
Nippon Oil Co.,
Tokuzo Shima,
Prince Tadashige Shimazu,
South Manchuria Railway Co.,
Sumitomo Firm,
Takata & Co.,
Kiosaku Takeda,
Takeuchi Mining Co.,
Heihachi Tanaka,
Ginnosuke Tanaka,
Yokohama Mining Department.

Corporations Interested in the Reception Committee.

America's Friends Society,
Association of Mine Owners,
Bureau of Mines,
Chikuho Coal Mining Association,
Electric Society,
Engineering Society,
Furukawa Mining Co.,
Geological Society,
Hokkaido Colliery and Steamship Co.,
Imperial Geological Survey of Japan,
Imperial Railways Association,
Imperial Steel Works,
Industrial Club,

Japan Foreign Trade Association,
Kobe Chamber of Commerce,
Kyoto Chamber of Commerce,
Mining Institute of Japan,
Mitsu Bishi Co.,
Mitsui Mining Co.,
Morimura & Co.,
Nippon Electric Association,
Nippon Oil Co.,
Nippon Yusen Kaisha,
Okura & Co.,
Osaka Chamber of Commerce,
Osaka Shosen Kaisha,
South Manchuria Railway Co.,
Sumitomo Firm,
Takata & Co.,
Tokyo Chamber of Commerce,
Tokyo Geographical Society,
Toyo Kisen Kaisha,
Yokohama Specie Bank.

Individuals of the Reception Committee.

Jinzo Adachi, Mining Engineer.
Kotojiro Arai, Superintendent of Mining Department of Besshi Copper-Mine.
Nagabumi Ariga, Councilor of Mitsui Gomei Kaisha.
Eiji Asabuki, Director of Mitsui Bussan Kaisha.
Soichiro Asano, President of Ishikari Coal Mining Co.
President of Iwaki Coal Mining Co.
President of Toyo Kisen Kaisha.
Takichi Aso, President of Chikuho Coal Mining Association.
Owner of Yoshio and Mameda Collieries.
Member of House of Peers.
Takuma Dan, Councilor of Mitsui Gomei Kaisha.
Director of Association of Mine Owners.
Sadae Eguchi, Manager of Business Department of Mitsu Bishi Co.
Jokichi Fujioka, Chief Mechanical Engineer of Miike Coal-Mine.
Baron Denzaburo Fujita, President of Fujita Co.
Heitaro Fujita, Vice-President of Fujita Co.
Kikusaburo Fukui, Director of Mitsui Bussan Kaisha.
Kimitake Furuichi, Member of House of Peers.
Honorary Prof. of Tokyo Imperial University.
Toranosuke Furukawa, President of Furukawa Mining Co.
Baron Seinosuke Go, President of Iriyama Coal Mining Co.
Member of House of Peers.
President of Teikoku Shogio Ginko.
Riusuku Godai, Representative of Shimazu Mining Department.
Viscount Yoshikata Hanabusa, Vice-President of Tokyo Geological Society.
Vice-President of Japan Red Cross Society.
Yoshimichi Hara, President of Tokyo Barristers Association.
Shinji Harada, Manager of Mining Department of Mitsu Bishi Co.
Tetsutaro Hasegawa, Engineer of Nikko Copper Works.
Heizaemon Hibiya, Vice-President of Tokyo Chamber of Commerce.
President of Fuji Spinning Co.
Seijiro Hirai, Vice-President of Imperial Government Railways.
Ritaro Hirota, Manager of Takata & Co.
Rentaro Hotta, Director of Mining Institute of Japan.
Giichi Iida, Managing Director of Mitsui Bussan Kaisha.
Masashige Iioka, Mining Engineer.
Kaichiro Imaizumi, Mining Engineer.
Kenji Imanishi, General Manager of Yokohama Specie Bank.
Kinosuke Inouye, Director of Imperial Geological Survey of Japan.

Viscount Tadashiro Inouye, Prof. of Metallurgy of Kyoto Imperial University.
Nobutaro Inuzuka, Director of South Manchuria Railway Co.
Masaharu Isobe, Director of Bureau of Mines.
Masakatsu Isobe, General Manager of Business Department of Takeda Mining Co.
Denuyemon Ito, Owner of Muta and Nakazuru Collieries.
Kenzo Iwahara, Director of Mitsui Bussan Kaisha.
Shoichi Iwanaga, Managing Director of Nippon Yusen Kaisha.
Baron Hisaya Iwasaki, President of Mitsu Bishi Co.
Baron Koyata Iwasaki, Vice-President of Mitsu Bishi Co.
Kotora Jimbo, Prof. of Mineralogy of Tokyo Imperial University.
Director of Mining Institute of Japan.
Teiichi Kada, Mining Engineer.
Jukuro Kadono, Director of Okura & Co.
Eizaburo Kaijima, Director of Kaijima Mining Co.
Kenji Kaijima, Chief Engineer of Kaijima Mining Co.
Tasuke Kaijima, President of Kaijima Mining Co.
Tatsuzo Kamiyama, Engineer of Bureau of Mines.
Baron Naibu Kanda, Vice-President of America's Friends Society.
President of English Speaking Society.
Member of House of Peers.
Reiji Kanda, Mining Engineer.
Viscount Kentaro Kaneko, President of America's Friend Society.
Privy Councilor.
Washitaro Kasahara, Chief Engineer of Hibira Copper-Mine.
Shin-ichi Kano, Inspector of Osaka Mine Inspection Office.
Keisuke Kato, Director of Mining Institute of Japan.
Masayoshi Kato, Vice-President of Nippon Yusen Kaisha.
Benzo Katsura, Prof. of Metallurgy of Tokyo Imperial University.
Yoiehi Katsura, Director of Fujita Co.
Yasushiro Kawai, Manager of Sakito Colliery.
Takeshi Kawamura, Mining Engineer of Osaruzawa Copper-Mine.
Kazue Kibe, General Manager of Furokura Copper-Mine.
Choshichi Kimura, Chief Director of Furukawa Mining Co.
Kasuyata Kimura, Manager of General Affairs Department of Mitsu Bishi Co.
Yoji Kimura, General Manager of Kosaka Mine.
President of Kosaka Railway Co.
Auditor of Kitahama Bank.
Junjiro Kobuse, Mining Engineer.
Jintaro Kojima, Superintendent of Ashio Copper-Mine.
Koroku Komura, Manager of Tanaka's Mining and Metallurgical Department.
Sankichi Komuro, Director of Mitsui Bussan Kaisha.
Rokusaburo Kondo, Director of Furukawa Mining Co.
Director of Yokohama Electric Wire Works.
President of Ashio Railroad Co.
Director of Association of Mine Owners.
Munio Kubo, Director of Sumitomo Firm.
General Manager of Besshi Copper-Mine.
Fusanosuke Kuhara, owner of Hitachi Mine.
Masa Kuwabara, owner of Kuwabara Colliery.
Sukenobu Maki, Sub-Manager of Sumitomo Besshi Copper-Mine.

Tamaki Makita, General Manager of Miike Coal-Mine.
Naka Matoba, President of Meiji Higher Technical School.
Otohiko Matsukata, Managing Director of Nippon Oil Co.
Kenjiro Matsumoto, Vice-President of Meiji Mining Co.
Kumpei Mimura, Manager of Banking Department of Mitsu Bishi Co.
Baron Hachiroemon Mitsui, President of Mitsui Gomei Kaisha.
Saburosuke Mitsui, President of Mitsui Mining Co.
Ichizaemon Morimura, President of Morimura & Co.
Yoshibumi Murota, Chairman of Board of Directors of Hokkaido Colliery & Steamship Co.
Kiutaro Nagai, Managing Director of Japan Sulphur Co.
Hisahiro Naito, President of Nippon Oil Co.
Viscount Seikyo Naito, owner of Hibira Copper-Mine.
Kinkichi Nakada, Director of Sumitomo Firm.
Manager of Sumitomo Bank.
Jeko Nakamura, President of South Manchuria Railway Co.
Keijiro Nakamura, Superintendent of Shisaka Smelting Works.
Baron Yujiro Nakamura, President of Imperial Steel Works.
Hisashi Nakane, Director of Kaijima Mining Co.
Tokujiro Nakano, owner of Aida Colliery.
Baron Kumakichi Nakashima, President of Yokohama Electric Wire Works.
Director of Ashio Railroad Co.
Kiugo Nambu, General Manager of Mitsu Bishi Co.
Director of Association of Mine Owners.
Kaichiro Nezu, Vice-President of Tokyo Chamber of Commerce.
Keijiro Nishio, Engineer of Bureau of Mines.
Kageyoshi Noro, Director of Mining Institute of Japan.
Kwan-ichi Okamoto, Director of Mitsui Mining Co.
Kunisuke Okazaki, Director of Furukawa Mining Co.
Auditor of Ashio Railroad Co.
Kumema Okura, Director of Okura & Co.
Michitaro Oshima, Prof. of Metallurgy of Tokyo Imperial University.
Director of Mining Institute of Japan.
Rokuro Oshima, Director of Hokkaido Colliery & Steamship Co.
Masayuki Otagawa, Manager of Mining and Engineering Department of Furukawa Mining Co.
Director of Ashio Railroad Co.
Kahei Otani, President of Yokohama Chamber of Commerce.
Hyakuju Ro, Director of Kano Mining Co.
Daikichi Saito, Prof. of Metallurgy of Kyoto Imperial University.
Shigetaro Sakikawa, Director of Hasami Gold-Mine.
Chotaro Seino, Director of South Manchuria Railway Co.
Baron Eiichi Shibusawa, President of Dai Ichi Bank.
President of Tokio Saving Bank.
President of Teikoku Gekijo, etc.
Tokuzo Shima, Owner of Mochibe Copper-Mine.
Prince Tadashiye Shimazu, Owner of Yamagano and Serigano Gold-Mines.
Seijiro Sho, Manager of Privy Department of Mitsu Bishi Co.
Masaya Suzuki, Chief Director of Sumitomo Firm.
Chusuke Suehiro, Prof. of Metallurgy of Kiushu Imperial University.

Michinari Suenobu, President of Toyokawa Railroad Co., Tomei Fire & Marine Insurance Co., Tokyo Marine Insurance Co., Director of Meiji Life Insurance Co., Meiji Fire Insurance Co.
Tatsukichi Suganuma, Vice-President of Nippon Electric Association, President of Osaka Electric Light Co.
Isuzu Sugimoto, Engineer of Bureau of Mines.
Baron Kichizaemon Sumitomo, Owner of Sumitomo Firm.
Kiichiro Takagi, Manager of Hondo Coal-Mine.
Kamakichi Takata, Vice-President of Takata & Co.
Nobujiro Takata, Partner of Takata & Co.
Shinzo Takata, President of Takata & Co.
Kiosaku Takeda, Owner of Tsubaki Mine.
Director of Kano Mining Co.
Korehiko Takeuchi, General Manager of Hitachi Mine.
Meitaro Takeuchi, Director of Takeuchi Mining Co.
Tsuna Takeuchi, President of Takeuchi Mining Co.
Chobei Tanaka, Owner of Kamaishi Iron-Mine, and Kinkaseki Gold-Mine.
Ginnosuke Tanaka, Owner of Kiosei and Tomioka Mines.
Director of Hokkaido Colliery & Steamship Co.
Heihachi Tanaka, Owner of Kunitomi Mine.
Riuzo Tanaka, Ex-Director of Bureau of Mines.
Kingo Tatsuno, Honorary Prof. of Tokyo Imperial University.
Kuniichi Tawara, Prof. of Metallurgy of Tokyo Imperial University.
Count Masatake Terauchi, Resident-General of Chosen.
Nobukichi Toge, Director of Kaijima Mining Co.
Shigeyasu Tokunaga, Prof. of Geology of Waseda University.
Riohei Toyokawa, General Manager of Mitsu Bishi Co.
Kennosuke Tsujimoto, Engineer of Fujita Co.
Kyo Uematsu, Sub-Manager of Business Department of Mitsu Bishi Co.
Shumpei Uemura, Mayor of Osaka City.
Tsuruta Uno, Managing Director of Hokkaido Colliery & Steamship Co.
Tsunashiro Wada, Honorary Member of American Institute of Mining Engineers, Representative of Association of Mine Owners, Ex-President of Imperial Steel Works, Ex-Director of Bureau of Mines, Ex-Prof. of Mineralogy of Tokyo Imperial University.
Toshio Watanabe, Prof. of Mining and Metallurgy of Kyoto Imperial University.
Wataru Watanabe, Dean and Prof. of Engineering College of Tokyo Imperial University, President of Mining Institute of Japan.
Yoshitaro Watanabe, Prof. of Metallurgy of Kiushu Imperial University.
Naoya Yamada, Managing Director of Mitsui Mining Co.
Eigo Yamagiwa, Director of Iriyama Coal Mining Co.
Kisaburo Yamaguchi, Assistant Manager of Mining and Engineering Department of Furukawa Mining Co.
Jotaro Yamamoto, Director of Mitsui Bussan Kaisha.
Shigema Yamanouchi, Sub-Manager, Superintendent of Mining Department of Takata & Co.
Naokata Yamasaki, Secretary of Tokyo Geological Society.

Minokichi Yanagiya, Manager of Takata & Co.
Keiichiro Yasukawa, President of Meiji Mining Co.
Jisaburo Yokobori, Prof. of Metallurgy of Kyoto Imperial University
Akira Yokoyama, Director of Yokoyama Mining Department.
Kiutaro Yokoyama, General Manager of Kamaishi Iron-Mines.
Manji Yoshimura, Mining Inspector of Tokyo Mine Inspection Office.

The New York Section.

The New York Section of the American Institute of Mining Engineers will hold a meeting at the Engineering Societies Building, 29 West 39th Street, New York, on Tuesday, March 26, 1912, at 8.15 p. m., at which Prof. James F. Kemp will present an illustrated lecture on Iron-Mines in Swedish Lapland.

The technical session will adjourn at 10 o'clock, after which a smoker will be held in the Institute offices on the ninth floor of the building. Light refreshments will be served.

The April meeting of the Section will be held on Friday, April 12, 1912, at which Dr. Carleton Ellis will deliver an illustrated lecture on Flameless Combustion. This new process has been developed by Dr. William A. Bone, in England, and is attracting a great deal of attention in the metallurgical field. It seems probable it will have a revolutionary effect on some furnace operations.

BENJAMIN B. LAWRENCE, *Chairman.*
BRADLEY STOUGHTON, *Secretary.*

165 Broadway, New York, N. Y.

Back Volumes of the Transactions.

The Board of Directors has authorized the following offers of sets of back volumes of the *Transactions*, at considerably reduced prices, to Members, Libraries, and Scientific Societies:

		Per Set.
I.	Five volumes, bound in half-morocco, from No. 36 (1906) to No. 40 (1910), ...	$20
II.	Ten volumes, bound in half-morocco, from No. 31 (1902) to No. 40 (1910), including Mexican Volume, . . .	35
III.	Twenty volumes, bound in half-morocco, from No. 21 (1893) to No. 40 (1910), ...	50
IV.	Thirty volumes, bound in half-morocco, from No. 11 (1883) to No. 40 (1910), ...	60
V.	Thirty-nine volumes, bound in half-morocco, from No. 1 (1873) to No. 40 (1910), with the exception of No. 10 (1882), but including index for Volumes Nos. 1 to 35, and Nos. 36 to 40, ...	75
VI.	Nine volumes, bound in half-morocco, from No. 1 (1873) to No. 9 (1881), ...	25

Applications should be addressed to Joseph Struthers, Secretary, 29 West 39th Street, New York, N. Y.

Special Notice.

The *Bulletin* is now entered at the Post Office at Second-Class Postage rate of one cent per pound, and in order to preserve this privilege it will be necessary that the dues of members be paid within four months of Jan. 1, 1912. If the dues are not paid within the period mentioned, a member's name must be removed from the regular subscription-list and the *Bulletin* mailed at the transient second-class postage rate of one cent for each four ounces or fraction thereof, prepaid by stamps affixed. It is therefore earnestly requested that dues be paid promptly—otherwise the Institute will be put to additional expense of postage and to added labor in removing and replacing names from the regular list, and in maintaining an additional separate mailing-list.

Library Research-Work.

The attention of members of the Institute is again directed to the research-work done by the librarian and his assistants, which should attract special attention from those members who have no access to the literature of subjects in which they may be interested.

During the year 1911 there were 143 searches made for members and non-members of the Founder Societies, and copies of the references have been preserved for the use of others. This work has been largely based on requests sent in by mail, from Japan, South Africa, Mexico, Canada, and England, as well as from different parts of the United States. The Librarian is confident that if it were more widely known that the library is equipped to undertake researches, the demand would increase beyond the ability of the present force to handle it. The library receives more than 700 technical periodicals which are available through the indexes for this special purpose.

The following searches were completed in the Library during the month of February, 1912:

Adirondack gold-sands.
Boiler and steam-engine—books since 1906.
Brick-burning by the use of crude oil.
Buildings—vibration in buildings.
Current—alternating vs. direct current systems.
Earth-temperatures.
Electricity on the farm.
Engineers—licenses of engineers.
Engineering societies—leading foreign electrical engineering society addresses.
Engineering ethics.
Fuel—liquid vs. coal fuel.
Gas-engine—books since 1906.
Gas-flow through pipes with small diameters and through small orifices.
Gas-producers—books since 1906.
Gas-producers—Lowe system.
Gearing.
Gold-bullion and platinum refining and separation.
Grinding.
Heat-insulation in building material.
Heating—central station heating.
Herringbone gears.
Lifting-magnets.
Mines at Santa Barbara, Chihuahua.
Oil-flotation—Eucalyptus process; Everson process.
Oil gas-producers.
Oil-separation from condensed steam.
Pattern-storage systems.
Platinum and gold separation.
Plows, operated by electricity.
Profit-sharing.
Pumping-costs, operation, maintenance.
Railways—elevated railways in Manhattan; their history.
Springs—light springs.
Spring motors.
Steam-engines—books since 1906.
Steam-regeneration.
Street-cleaning systems.

Street-sprinkling methods, water quantity, costs.
Sulphur-mines in Mexico.
Tesla's experiments in high frequency.
Ties—concrete railway-ties; metal railway-ties.
Trackless trolleys.
Turbines — steam-turbine — books since 1906.
Water-purification for industrial uses.
Welding.
Welding—electric welding.
Wiring—electric-wiring books.

Local Sections.

The following regulations for the establishment of Local Sections of the Institute, issued in circular form and distributed to the membership May 26, 1911, are here republished for more convenient reference.

Regulations for the Formation and Conduct of Local Sections.
(Adopted May 19, 1911.)

1. A Local Section of the Institute may be authorized by the Council at the written request of *ten* members residing within an appropriate distance of a central point.
2. Only one Section shall be authorized in one locality or district.
3. The Council shall define the territory of a Section.
4. A Section must consist of twenty-five or more members; when its membership falls below twenty-five in number the Council may annul the Section.
5. Only members of the Institute shall be members of its Local Sections.
6. All members of the Institute, of all grades, residing within the territory of a Section shall *ipso facto* constitute the membership of such Section.
7. The officers of a Section shall be elected after the formation of the Section has been duly authorized, at a meeting of the members of the Institute within the territory of said Section, called by the sponsors of the Section, notice of said meeting and its object being given to said members at least thirty days in advance. Officers shall be elected for a term not longer than one year.
8. The officers of a Local Section shall be a Chairman, Vice-Chairman, Secretary, Treasurer (or Secretary-Treasurer), and such others as the Section may desire.
9. Whenever the Institute is financially able to do so, it shall be the policy of its Board of Directors to contribute from its funds for the legitimate running expenses of each Local Section an amount not exceeding, in each year, 25 per cent. of the dues received from the members of said Section in said year. Requests for such appropriations shall be signed by the Chairman, Secretary and Treasurer of the Section.
10. If the expenses of a Section exceed the appropriation made it by the Institute, the difference must be made up by voluntary contributions, but not by assessment upon the members of said Section. The Institute shall not be responsible for the debts of its Sections.
11. The Institute reserves the right to cancel a Section, or re-adjust its territory.

12. Papers presented at Local Sections, and discussions thereon if reported, are the property of the Institute. They shall be submitted to the Publication Committee and published in the *Bulletin* or *Transactions*, or both, if approved. Such papers shall not be published elsewhere without permission of the Council. The reading of a paper before a Local Section shall not carry with it the right of publication in the *Bulletin* or *Transactions* of the Institute.

13. Neither the author of a paper presented to a Local Section nor the Local Section shall have the right to reprint a paper or publish it in advance of the meeting without obtaining the permission of the Publication Committee of the Institute, which shall determine the details of such permission. Nothing herein shall forbid the abstracting of a paper by the press *after* its presentation before the Local Section.

14. The Institute shall print advance copies of papers offered to Local Sections, in order to facilitate discussion thereon, provided that such papers are approved for such advance publication by the Chairman or Secretary of the Local Section and by the Publication Committee of the Institute.

15. Papers read before a Local Section may also be offered for reading or discussion at general meetings of the Institute, and shall be given equal standing with the other papers on the program of said meeting, when approved by the Publication Committee.

16. Each Local Section shall transmit promptly to the Secretary of the Institute full announcements of its proposed meetings and an abstract of its proceedings, including the names of authors and titles of all papers read before it, for the purpose of preparing a report thereon to be published in the *Bulletin* of the Institute, and for the purpose of enabling the Council of the Institute to comply with articles 17 and 19 of these regulations.

17. The By-Laws and regulations of Local Sections shall be subject to the approval of the Council.

18. The Council reserves the right to amend, annul, or add to these regulations.

19. No action shall be taken by a Section which shall contravene the Constitution of this Institute.

The Emmons Research Fellowship of Economic Geology.

The Committee named below has been formed by friends of Samuel Franklin Emmons, late of the United States Geological Survey, to consider the best method of perpetuating his name. It has been decided that the memorial to him shall take the shape of a Research Fellowship, to be known as the Samuel Franklin Emmons Research Fellowship of Economic Geology, which is to be administered by Prof. James F. Kemp, of Columbia University, New York. Subscriptions are invited by his friends to this fund, which the Committee has fixed at $25,000.

Members of the Institute who desire to contribute to this fund will please communicate with the Treasurer, Benjamin B. Lawrence, 60 Wall Street, New York.

The Committee consists of the following:

GEORGE OTIS SMITH, Director, U. S. Geological Survey, Washington, D. C.
H. L. SMYTH, Harvard University, Cambridge, Mass.
JAMES DOUGLAS, 99 John Street, New York, N. Y.
J. A. HOLMES, Director, Bureau of Mines, Washington, D. C.
JAMES F. KEMP, Columbia University, New York, N. Y.
F. W. BRADLEY, San Francisco, Cal.
J. PARKE CHANNING, 42 Broadway, New York, N. Y.
SEELEY W. MUDD, 1001 Central Building, Los Angeles, Cal.
D. W. BRUNTON, Denver, Colo.
H. FOSTER BAIN, 420 Market Street, San Francisco, Cal.
T. A. RICKARD, London, England.
B. B. LAWRENCE, 60 Wall Street, New York, N. Y.

Regulations for the Committee on Publication.

(*Adopted June* 16, 1911.)

1. The formation of a Publication Committee, consisting of the Secretary-Editor of the Institute, *Chairman*, and of at least twelve specialists, members of the Institute, who are willing to assist in passing on all papers offered for publication.

2. This committee shall perform its functions as follows:

(*a*) On the receipt of a paper by the Secretary, he shall send it to the member of this committee who, in his judgment, is most competent to pass upon it, accompanying the paper with his own opinion of its suitableness for publication, the history of the paper, and any other pertinent information.

(*b*) If the member of the committee and the Chairman agree upon the suitability or unsuitability of the paper, it shall be considered accepted for publication or rejected, as the case may be.

(*c*) If these two do not agree, the paper shall be submitted to a third, and the opinion of two of these three shall decide the matter.

(*d*) If a paper has been refused publication, the author may have the right of appeal, in which case the persons previously passing on the paper, together with others of the committee (appointed by the President) making five altogether, shall decide the question.

(*e*) If a paper has been accepted for publication, it shall be considered eligible to be placed on the program of a meeting.

3. The placing of a paper upon the program of a meeting does not give it the right to be published in the *Bulletin* or *Transactions* of the Institute; its suitability for publication must in every case be passed upon by the Publication Committee, as provided for in Section 2.

4. In case the Secretary is unable to secure a decision as to the suitability or unsuitability of a paper for publication, as directed in Section 2, before the time of announcing the program of a meeting, he may at his own discretion place the paper upon the program of the meeting, or refuse it a place thereon.

Affiliated Student Societies.

Any society of undergraduates at a technical school, comprising students in any branch of engineering, metallurgy, chemistry, geology, etc., may be recognized by the Council in its discretion as an Affiliated Student Society. A circular giving details of the plan of affiliation may be obtained on application to the office of the Secretary of the Institute.

The following societies have been placed by authority of the Council on the above list:

AFFILIATED STUDENT SOCIETIES.

The Mining Society of the Sheffield Scientific School, Yale University, New Haven, Conn. *President*, Karl C. Stadtmiller; *Secretary*, S. B. Gordy.

The University of Illinois Student Branch of the American Institute of Mining Engineers, Champaign, Ill. *President*, Leonard V. Newton; *Secretary*, L. W. Swett.

The Engineering Society of the University of Nevada, Reno, Nev. *President*, Walter Harris; *Secretary*, E. R. Bennett.

The University of Wisconsin Mining Club, Madison, Wis. *President*, H. E. Schmidt; *Secretary*, W. V. Bickelhaupt.

The Mining and Geological Society of Lehigh University, South Bethlehem, Pa. *President*, William E. Fairhurst; *Secretary*, Carl W. Mitman.

The School of Mines Society of the University of Minnesota, Minneapolis, Minn. *President*, Emory P. Baker.

The Mining Engineering Society of the Massachusetts Institute of Technology. *President*, L. B. Duke; *Secretary*, Lionel H. Lehmaier.

The Student Auxiliary Society of the American Institute of Mining Engineers of the University of Kansas, Lawrence, Kan. *President*, A. H. Mangelsdorf; *Secretary*, C. J. Hainbach.

The Associated Miners of the University of Idaho, Moscow, Idaho. *President*, James W. Gwinn; *Secretary*, J. Wallace Strohecker.

The State College of Washington Mining and Geological Society, Pullman, Wash. *President*, H. E. Doelle; *Secretary*, B. R. Kinney.

The Tejas Technical Society, School of Mines, University of Texas. *President*, G. C. Cartwright; *Secretary*, David S. Alley.

The Ohio State University Student Branch of the American Institute of Mining Engineers, Columbus, Ohio. *President*, Hugh B. Lee; *Secretary*, E. P. Elliott.

The Stanford Geology and Mining Society, Stanford University, Cal. *President*, B. E. Parsons; *Secretary*, E. D. Nolan.

The Senior Mining Society of Columbia University, New York, N. Y. *President*, Roger L. Strobel; *Secretary*, Clark G. Mitchell.

Mining Association of the University of California, Berkeley, Cal. *President*, W. E. De Berry; *Secretary*, J. F. Dodge.

Tufts College Chemical Society, Tufts College, Mass. *President*, P. G. Savage; *Secretary*, W. S. Frost.

University of Washington Mining Society, Seattle, Wash. *President*, Horace H. Crary; *Secretary*, Clinton R. Lewis.

Student Branch of the American Institute of Mining Engineers, Iowa State College, Ames, Iowa. *President*, M. B. Hadley; *Secretary*, R. L. Hurst.

Missouri Mining Association of the Missouri School of Mines, Rolla, Mo. *President*, D. L. Forrester; *Secretary*, J. S. Irwin.

The Pick and Shovel Club of the Case School of Applied Science, Cleveland, Ohio. *President*, L. B. Riddle; *Secretary*, S. C. Stillwagon.

Colorado School of Mines Scientific Society, Golden, Colo. *President*, Alan Kissock; *Secretary*, George Wilfley.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
AMERICAN INSTITUTE OF MINING ENGINEERS.
UNITED ENGINEERING SOCIETY.
WILLIAM P. CUTTER, Librarian.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

The Library contains about 42,000 volumes, including sets of technical periodicals and the publications of scientific and technical societies.

The members of the Institute, with few exceptions, are by the very nature of their profession forced to spend a large portion of their time in localities isolated from sources of information. To such members the Library can render valuable service through correspondence, and letters requesting information will receive special attention. The Library is prepared to furnish references and copies of articles on mining and metallurgical subjects; to determine, if possible, the existence of mining-maps, and to furnish general information as to the geology and mineral resources of all countries as far as these resources are known and published.

It is hoped that the members of the Institute will avail themselves freely of this special service. The Library will welcome inquiries on engineering subjects, and furnish information as far as such information is to be obtained.

All communications should be made as definite as possible so that the information received may be what is desired and not include collateral matter which may not be of interest. In this way the time spent in searching for such collateral matter will be saved, and as a result the information will be sent more promptly and in more usable shape.

The members of the Institute can be of service to the Library by forwarding copies of mining-reports, maps privately issued, and similar material, which will be classified, indexed, and made available to other members.

Suggestions for additions to the Library, either by purchase or personal solicitation as gifts, will be welcomed. It is hoped that members while in the city will use the Library freely, and assurance is given that most careful service will be rendered to them.

Library Accessions.

Feb. 1 to Feb. 29, 1912.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

AMERICAN MUSEUM OF NATURAL HISTORY. Bulletin. Vol. 30, 1911. New York, 1911. (Exchange.)

AMERICAN SOCIETY FOR TESTING MATERIALS. Proceedings of 14th Annual Meeting. Vol. XI. Philadelphia, 1911. (Exchange.)

ANNUAIRE UNIVERSEL DES MINES ET DE LA MÉTALLURGIE. Ed. 3. By Robert Pitaval. Paris, 1911. (Purchase.)

ASPHALT PAVEMENTS. By M. S. Darrow. (Reprinted from *Cornell Civil Engineer*, Oct., 1911.) Ithaca, 1911. (Gift of Author.)

AUSTRALASIAN INSTITUTE OF MINING ENGINEERS. Transactions. Vol. 15, part I–II. Melbourne, 1911. (Exchange.)

BERG UND HÜTTENMAENNISCHE ZEITUNG. Vols. 21–29. Freiberg, 1862–1870. (Gift of George W. Maynard.)

BROOKLYN DAILY EAGLE ALMANAC, 1912. Brooklyn, 1912. (Purchase.)

CALCITES OF NEW YORK. (New York State Museum. Memoir No. 13.) By H. P. Whitlock. Albany, 1910. (Exchange.)

CAMBRIA STEEL. A Handbook of Information Relating to Structural Steel Manufactured by the Cambria Steel Co. By G. E. Thackray. Johnstown, 1909. (Gift of Author.)

CEMENTS, LIMES AND PLASTERS. Their Materials, Manufacture and Properties. By E. C. Eckel. New York, 1909. (Purchase.)

CHAMPS D'OR RIGAUD VAUDREUIL, LTD. Brief History of. · Montreal, n. d. (Gift of T. E. Helmick.)

CHEMICAL NEWS. Vols. 7–20, 22. London, 1863–1870. (Gift of George W. Maynard.)

CHEMISCHE TECHNOLOGIE DER NEUZEIT. Vol. I. By Otto Dammer. Stuttgart, 1910. (Purchase.)

CHISPAS CYANIDE PLANT, ARIZPE, SONORA, MEXICO. By E. L. Dufourcq. (Reprinted from *School of Mines Quarterly*, Nov., 1911.) (Gift of Author.)

COMPOSITION OF TEXAS COALS AND LIGNITES AND THE USE OF PRODUCER GAS IN TEXAS. By Wm. B. Phillips. (University of Texas. Bulletin, Scientific Ser., No. 19.) Austin, 1911. (Exchange.)

CORNELL CIVIL ENGINEERING. Class of 1911. Ithaca, n. d. (Gift of Cornell University.)

DESCRIPTIVE MINERALOGY WITH ESPECIAL REFERENCE TO THE OCCURRENCES AND USES OF MINERALS. By E. H. Kraus. Ann Arbor, 1911. (Purchase.)

DREDGE AND DREDGING. By Charles Prelini. New York, Van Nostrand, 1911. (Purchase.)

ENGINEERING AS A VOCATION By Ernest McCullough. New York, David Williams Co., 1911. Price, $1. (Gift of Publisher.)

[NOTE.—The author of this book is a civil engineer of standing, and member of many engineering societies. The book itself is a rearrangement and amplification of addresses delivered by him before technical audiences; and it is published "for the information of parents, in order that they may act wisely in selecting a career for their sons." The way in which parents decide this question, or let it decide itself, without adequate knowledge or appropriate inquiry on their part, is notorious; and yet they are scarcely to be blamed if, standing helpless before the complicated novelties of modern technical education and modern professional and commercial demands, they leave largely to chance, or to the boy himself, the solution of a problem which they do not dare to attack. To such dazed minds, and

also to the minds of educators and practitioners—even to the mind of the boy himself—the shrewd practical suggestions of Mr. McCullough should be most valuable. He treats, in successive chapters: The Engineer; the Work of the Engineer; the Education of the Engineer; Home Study-Courses; How to Hunt and Hold a Job; and Does it Pay to Study Engineering? And not the least valuable part of the book is the Appendix, which contains the views and suggestions of several editors of engineering journals.—R. W. R.]

ENGINEERING INDEX, 1911. New York-London, 1912. (Purchase.)

ENGLISH-HUNGARIAN DICTIONARY. 2 pts. By Franz de Paula Bizonfy. N. p., n. d. (Purchase.)

FABRICATION DU CIMENT. By J. Fritsch. Paris, 1911. (Purchase.)

GEMEINFASSLICHE DARSTELLUNG DES EISENHÜTTENWESENS. Ed. 7. Herausgegeben vom Verein deutscher Eisenhüttenleute in Düsseldorf. Düsseldorf, 1910. (Purchase.)

GEOLOGY FOR ENGINEERS. By R. F. Sorsbie. London-Philadelphia, 1911. (Purchase.)

GEOLOGY OF THE COASTAL PLAIN OF GEORGIA, PRELIMINARY REPORT ON. (Bulletin No. 26, Georgia Geological Survey.) Atlanta, 1911. (Exchange.)

GOLDFIELD CONSOLIDATED MINES CO. Annual Report, 5th, 1911. Goldfield, 1911. (Gift of Company.)

HISTORY OF THE PRECIOUS METALS FROM THE EARLIEST TIME TO THE PRESENT. Ed. 2. By Alex. Del Mar. New York, Cambridge Encyclopedia Co., 1902.

This is the second edition of a work published in 1880 in London, and which has been looked at as the great authority on the early history of the precious metals in the world. Two features in Mr. Del Mar's book appeal to the bibliographer: the first is that he prefixes a complete bibliography of the subject to his book, giving not only the titles of the works referred to but the press marks of the British Museum, and second, almost every page is covered with elaborate footnotes giving in perfect form references to all of the authorities backing the statements made. When we consider that there is in addition a most complete index, the book has nothing left to criticise from the librarian's stand-point. It is probably the only compilation relating to the subject, and should be, I suppose, in the library of almost any mining engineer.—W. P. C.

ILLINOIS. BUREAU OF LABOR STATISTICS. Industrial Opportunities. Springfield, 1911. (Gift of Bureau of Labor Statistics.)

ILLINOIS STATE MINING BOARD. Annual Coal Report, 30th, 1911. Springfield, 1912. (Gift of Illinois State Mining Board.)

INDUSTRIAL DEPRESSIONS. Their Causes Analyzed and Classified, with a Practical Remedy for Such as Result from Industrial Derangements or from the Barometer of Trade. By G. H. Hull. New York, 1911. (Gift of Charles Kirchhoff.)

INSTITUTE OF METALS. Journal. Vol. VI. London, 1911. (Exchange.)

INTRODUCTION À LA METALLOGRAPHIE MICROSCOPIQUE. By P. Goerens. Paris, 1911. (Purchase.)

INVESTIGATIONS OF EXPLOSIVES USED IN COAL MINES. (Bulletin No. 15, U. S. Bureau of Mines.) Washington, 1912. (Exchange.)

INVESTIGATIONS OF FUSE AND MINERS' SQUIBS. (Technical Paper No. 7, U. S. Bureau of Mines.) Washington, 1912. (Exchange.)

IRON AND STEEL INSTITUTE. Journal. Vol. 84 (No. II, 1911.) London, 1911. (Exchange.)

KÖNIGLICH PREUSSISCHEN GEOLOGISCHEN LANDESANSTALT ZU BERLIN. Jahrbuch. Vol. 30, 1909, pt. 1. Vol. 32, 1911, pt. 1–2. Berlin, 1909, 1911. (Exchange.)

LEAD SMELTING. The Construction, Equipment, and Operation of Lead Blast Furnaces. By M. W. Iles. New York, 1904. (Purchase.)

LITERATUR DER SULFIT ABLAUGE. By W. H. M. Müller. Berlin, 1911. (Purchase.)

METAL INDUSTRY DIRECTORY, 1912. New York, 1912. (Gift of Metal Industry Publishing Co.)

METALLURGY OF THE COMMON METALS. Gold, Silver, Iron, Copper, Lead, and Zinc. Ed. 3. By L. S. Austin. San Francisco, 1911. (Purchase.)

MINERAL RESOURCES OF THE UNITED STATES, 1910. Part I—Metals. Washington, 1911. (Exchange.)

MINERAL RESOURCES OF TEXAS. (Bulletin No. 14, Texas Department of Agriculture.) Austin, 1910. (Exchange.)

MINING INDUSTRY OF IDAHO. Annual Report, 13th, 1911. Boise, 1912. (Gift of State Inspector of Mines of Idaho.)

NEW YORK ACADEMY OF SCIENCES AND AFFILIATED SOCIETIES DIRECTORY. January, 1912. New York, 1912. (Exchange.)

OFFICIAL DIRECTORY OF MINES AND ESTATES OF MEXICO. Vol. XI, 1910. Mexico, 1910. (Purchase.)

POTASH BEARING ROCKS OF THE LEUCITE HILLS, SWEETWATER COUNTY, WYOMING. (Bulletin No. 512, U. S. Geological Survey.) Washington, 1912. (Exchange.)

PRODUCTION OF SPELTER IN THE UNITED STATES, 1911. Washington, 1912. (Exchange.)

QUEBEC. BUREAU OF MINES. Géologie du Canton de Fabre Comté de Pontiac. Quebec, 1911. (Gift.)

QUEBEC. DEPARTMENT OF COLONIZATION, MINES AND FISHERIES. Report on the Geology and Mineral Resources of the Chibougamau Region, Quebec. Quebec, 1911. (Gift.)

RATE OF BURNING OF FUSE AS INFLUENCED BY TEMPERATURE AND PRESSURE. (Technical Paper No. 6, U. S. Bureau of Mines.) Washington, 1912. (Exchange.)

SITKA MINING DISTRICT, ALASKA. (Bulletin No. 504, U. S. Geological Survey.) Washington, 1912. (Exchange.)

ON SINHALESE IRON AND STEEL OF ANCIENT ORIGIN. By Sir Robt. Hadfield. (From *Proceedings of the Royal Society*, A, vol. 86, 1912.) N. p., n. d. (Gift of Author.)

STATISTISK AARBOK FOR KONGERIKET NORGE. 31 Aargang, 1911. Kristiania, 1912. (Gift of Norway Statistiske Centralbyraa.)

STEVENS INSTITUTE OF TECHNOLOGY. Annual Catalogue, 1912–1913. Hoboken, 1912. (Gift of Stevens Institute.)

TRIBUNE ALMANAC, 1912. New York, 1912. (Purchase.)

U. S. CENSUS BUREAU. (Special Reports.) Manufactures, 1905. Pt. I, Washington, 1907. (Exchange.)

——— Mines and Quarries, 1902. Washington, 1905. (Exchange.)

——— Abstract of the 12th Census, 1900. Ed. 3. Washington, 1904. (Exchange.)

U. S. COAST AND GEODETIC SURVEY. Report of the Superintendent Showing the Progress of the Work from July 1, 1910, to June 30, 1911. Washington, 1912. (Exchange.)

U. S. COAST AND GEODETIC SURVEY. Results of Magnetic Observations made by the Coast and Geodetic Survey between July 1, 1910, and June 30, 1911. Washington, 1912. (Exchange.)

UNITED STATES NATIONAL MUSEUM. Bulletin Nos. 50, 77. Washington, 1911. (Exchange.)

——— Contributions from the National Herbarium, vol. 13, pt. 12. Washington, 1912. (Exchange.)

UNIVERSITY OF TEXAS. Bulletin. Scientific Ser. No. 19. July, 1911. Austin, 1911. (Exchange.)

UNTERSUCHUNGSMETHODEN DES EISENS UND STAHLS. By A. Rüdisüle. Berlin, 1910. (Purchase.)

VEIN FORMATION AT COBALT, ONTARIO. By J. B. Tyrrell. Toronto, 1911. (Reprinted from *Canadian Mining Journal*, Aug., 1907.) (Gift of Author.)

WEST AUSTRALIAN MINING PRACTICE. By E. D. Cleland. Kalgoorlie, 1911. (Purchase.)

WORLD ALMANAC, 1912. New York, 1912. (Purchase.)

TRADE CATALOGUES.

HAZARD MFG. Co., Wilkes-Barre, Pa.

Wire rope insulated wires. 96 pages.

Insulated wires and cables. 156 pages.

GENERAL ELECTRIC Co., Schenectady, N. Y.

Bulletin No. 4904. Small plant A. C. switchboards. 7 pages.

Bulletin No. 4917. Direct current exciter panels. 8 pages.

Bulletin No. 4918. Direct current switchboards. 14 pages.

Bulletin No. 4919. Small plant D. C. switchboards. 4 pages.

INGERSOLL-RAND Co., New York, N. Y. "Arc Valve" tappet rock drills. 16 pages.

United Engineering Society Library.

GIFT OF ENGINEERING NEWS.

AMERICAN WATER WORKS ASSOCIATION. Constitution, By-Laws, together with Proceedings of 1st–6th Annual Sessions. Minneapolis, 1887.

——— Report of Committee on a Uniform Scheme of Accounts and Reports for Water Supply Enterprises. 30th Annual Convention. New Orleans, 1910.

ANDRADE, J. Chronometric. Paris, 1908.

ANDRÉE, W. L. Die Statik des Kranbaues. München, 1908.

ANDREWS, H. B. Design of Reinforced Concrete Slabs, Beams and Columns. Boston, 1909.

APPLETON'S CYCLOPÆDIA OF APPLIED MECHANICS. Vols. 1–2. New York, 1880.

ARCHITECTS' DIRECTORY AND SPECIFICATION INDEX, 1909. New York, 1909.

ARTHUR, WILLIAM. New Building Estimator. New York, 1910.

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS. Report of Commissioner on Waterproofing of Concrete Covered Steel Floors of Bridges. Chicago, 1908.

ATCHERLEY, L. W. Some Disregarded Points in the Stability of Masonry Dams. London, 1904. (Drapers' Company Research Memoirs, Technical Ser. II.)

BACH, C. Elasticität und Festigkeit. Ed. 3. Berlin, 1898.

BALE, M. P. Gas and Oil Engine Management. Philadelphia, 1903.

BEAUVERIE, J. Le Bois. Paris, 1905.

BENJAMIN, PARK. Intellectual Rise in Electricity. New York, 1895.

BERGH, L. DE C. Safe Building Construction. New York, 1908.

BETHLEHEM STEEL Co. Special Structural Shapes for Buildings and Bridges. South Bethlehem, 1907.

BLACK, ADOLPH. Hydraulic Formulæ: Development and Discussion. (Reprint from School of Mines Quarterly, Vol. 28, No. 4.)

BLAINE, R. G. Hydraulic Machinery. London, 1897.

BOSTON SEWERAGE COMMISSION. Report 1876–1884. Boston, 1876.

BOWERS, A. L. Vitrified Salt Glazed Pipe vs. Concrete Pipe. N. p., 1908.

BROWN, J. M. Lectures on the Statutory Provisions Relating to Government Contracts. Baltimore, 1908.

CAIN, WILLIAM. Practical Designing of Retaining Walls. New York, 1888.

CHATLEY, HERBERT. Force of the Wind. London, 1909.

——— Problem of Flight. London, 1907.

COCQ, G. L. LE. Ponts Suspendus. Vol. 2. Paris, 1911.

COLLINS, H. E. Shaft Governors Centrifugal and Inertia. New York, 1908.

CORDIER, E. Turbines à Vapeur. Paris, 1911.

CRANDALL, C. L. Tables for the Computation of Railway and Other Earthwork. Ed. 2. New York, 1893.

CRUSSARD. L. Exploitation des Mines. Paris, 1911.

CUBITT, HORACE. Building in London. London, 1911.

DODGE, G. F. Diagrams for Designing Reinforced Concrete Structures. New York, 1910.

DROSNE, P. Machines Marines. Paris, 1910.

ELLS, R. W. Oil Fields of Eastern Canada. (From *Proceedings Nova Scotian Institute of Science*, Vol. 11, pt. 4.) Halifax, 1908.

FERRY, E. S. Brief Course in Elementary Dynamics for Students of Engineering. New York, 1908.

FIDLER, T. C. Calculations in Hydraulic Engineering. Pt. I. New York, 1898.

FLETCHER, ROBERT. Disposal of Household Wastes at Summer Resorts, Encampments and Farm Houses. Concord, 1905.

FRANKLIN, W. S., AND MACNUTT, B. Elements of Mechanics. New York, 1907.

FRIZELL, J. P. Water Power. New York, 1901.

GEORGIAN BAY SHIP CANAL SURVEY. Plates 1–56 to Accompany Report, 1908.

GILBRETH, F. B. Practical Talks on Contracting. Chicago, 1910.

GOLDINGHAM, A. H. Design and Construction of Oil Engines. New York, 1900.

GOULD, E. S. High Masonry Dams. New York, 1897.

——— Practical Hydraulic Formulæ for the Distribution of Water Through Long Pipes. New York, 1894.

GRAY, F. J. Computation of Area. London, 1909.

GUIFFART, A. Travaux Maritimes. Paris, 1911.

HELICAL GEARS: A Practical Treatise. New York, 1894.

HENLEY'S ENCYCLOPÆDIA OF PRACTICAL ENGINEERING. Vols. 3–4. New York, 1907–1908.

HOWE, GEORGE. Mathematics for the Practical Man. New York, 1911.

HUGHES, D. E., AND OTTO VON GELDERN. Determination of the Plane of Ordinary High Tide for Pacific Coast Harbors, with Particular Reference to San Diego Harbor, Cal. Discussion. (Reprinted from *Journal of the Association of Engineering Societies*, Vol. 44.) N. p., n. d.

ILLUSTRATED TECHNICAL DICTIONARY IN SIX LANGUAGES. By K. Deinhardt and A. Schlomann. Vols. I, II, IV, V, VI. New York, 1906, 1908, 1909.

JACOB, ARTHUR. Designing and Construction of Storage Reservoirs. New York, 1873.

JEANS, J. S. American Industrial Conditions and Competition. London, 1902. (Reports of British Iron Trade Commissioners.)

KENNEDY, RANKIN. Principles of Aeroplane Construction. New York, 1911.

KERNOT, W. C. Some Common Errors in Iron Bridge Design. Ed. 2. Melbourne, 1906.

LE CHATELIER, M. H. Recherches Experimentales sur la Constitution des Mortiers Hydrauliques. Paris, 1904.

LINN, H. R. Power Plant Design for Gas Power. N. p., n. d.

LORDLY, H. R. Subaqueous Concrete Work. (Paper Read before Canadian Society of Civil Engineers, Mar. 17, 1910.) N. p., n. d.

MEADE, R. K. Portland Cement. Easton, 1906.

MECHANICAL WORLD POCKET DIARY AND YEAR BOOK, 1906. Manchester, n. d.

MERCHANTS' ASSOCIATION OF NEW YORK. House Fly at the Bar Indictment—Guilty or Not Guilty. April, 1909. N. p., n. d.

METCALFE, HENRY. Course of Instruction in Ordnance and Gunnery. Ed. 2. New York, 1891.

MORRISON, C. E., AND BRODIE, O. L. High Masonry Dam Design. New York, 1910.

NATIONAL ASSOCIATION OF MASTER SHEET METAL WORKERS OF THE UNITED STATES. Tin Roofer's Handbook. Philadelphia, n. d.

NEW YORK (CITY) DEPARTMENT OF BRIDGES. Contract Drawings, Manhattan Bridge. 1906.

NIOTAN, E. Etude sur les Pistolets Automatiques. N. p., 1910.

NORMANDY, FRANK. Practical Manual on Sea Water Distillation. London, 1910.

NORTH RIVER BRIDGE AT NEW YORK CITY. 1895.

NORWELL, ALEXANDER. Elementary Applied Mechanics. New York-London, 1908.

OWENS, J. S., AND CASE, G. O. Coast Erosion and Foreshore Protection. London, 1908.

PALMEDO, D. P. How to Use Slide Rules. New York, 1907.

——— ——— Ed. 2. New York, 1909.

PARHAM, E. C., AND SHEDD, J. C. Miscellaneous Tests of Electric Car Equipment. New York, 1910.

PETIT, R. Le Constructeur de Petits Aeroplanes. Paris, n. d.

POCKET DICTIONARY OF TECHNICAL TERMS USED IN ARTS AND MANUFACTURES. Part 3. French-German-English. New York, 1872.

PROVIDENCE (R. I.) CITY ENGINEER'S OFFICE. Proposed Plan for a Sewerage System. Providence, 1884.

RADIGUER, CHARLES. La Navigation Sous-Marine. Paris, 1911.

RANKINE, W. J. M. Manual of Applied Mechanics. Ed. 5. London, 1869.

ROECHLING, H. A. Passage of Excreta Through House Drains. (From *Journal of Royal Sanitary Institute*, July, 1909.) London, 1909.

SIEBERT, J. S., AND BIGGIN, F. C. Modern Stone Cutting and Masonry. New York, 1896.

SIMIN, O. Water Hammer. N. p., n. d.

SLOCUM, S. E. General Formula for the Shearing Deflection of Beams of Arbitrary Cross Section, Either Variable or Constant. (From *Franklin Institute Journal*, April, 1911.)

SYNNESTVEDT, PAUL. Evolution of the Air Brake. New York, 1896.

TRAUTWINE, J. C. New Method of Calculating the Cubic Contents of Excavations and Embankments. Ed. 3. Philadelphia, 1869.

TRENTON IRON COMPANY. Wire Rope Transportation in all Its Branches. Trenton, 1896.

TWELVETREES, W. H. Concrete Steel Building. London-New York, 1907.

U. S. ENGINEER. DEPARTMENT OF THE DISTRICT OF COLUMBIA. Annual Report of the Operations. 1882-1884. Washington, 1882.

VOITH, J. M. Turbinen versuchsstationen und die Wasserkraft Zentralen mit Hydraulischer Akkumulierungsanlage. Berlin, 1909.

WHITE, FR. Manual for Business Corporations. Ed. 4. Albany, 1901.

WILCOX, LUTE. Irrigation Farming. New York, 1895.

WOOD, R. W. Physical Optics. New York, 1911.

TRADE CATALOGUES.

SIMPLEX CONSTRUCTION Co., New York, N. Y. Simplex system of concrete piling. 96 pages.

MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of February, 1912.

Members.

BELLINGER, HERMANN C., Met., Great Cobar, Ltd., Cobar, N. S. W., Australia.
BENNETT, ARTHUR F., Cons. Min. Engr.............2 Rector St., New York, N. Y.
GMEHLING, ANDREAS, Prof. of Met., The University, Santiago, Chile, So. America.
McINTYRE, JOHN E., Min. Engr., Supt., San Antonio Copper Co., S. A., San Antonio de la Huerta, Son., Mexico.
MACFEE, ROBERT, Met................Caucasus Copper Co., Ltd., Batum, So. Russia.
MATTIEVICH, EMERIO, Min. Engr., Mng. Partner, F. A. Mattievich & Co., Batum, Caucasus, Russia.
MERRILL, F. J. H., Min. Engr.........610 Citizens Bank Bldg., Los Angeles, Cal.
NEWBAKER, EDWARD J., Supt., Honey Brook Div., Lehigh & Wilkes-Barre Coal Co., Andenreid, Pa.
RODGERS, CHARLES E., Assayer..McKenzie, N. D.
RYALL, GEORGE M., Vice-Prest., Pac. S. & M. Co., 42 Broadway, New York, N. Y.
SCHNEIDER, GEORGE W., Min. Engr ....Golden, Colo.
SCHOFIELD, WILLIAM McN., Min. Engr., J. R. Gilman Interests, Eckman, W. Va.
WILLARD, LEWIS L., Chief Engr., W. J. Rainey Estate............Uniontown, Pa.

Associate.

SETHNA, NANABHOY K., Student...........Columbia University, New York, N. Y.

CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the month of February, 1912. This list, together with the foregoing list of new members, therefore, supplements the annual list of members corrected to Feb. 1, 1912, and brings it up to the date of Mar. 1, 1912.

ALDASORO, ANDRES, Genl. Mgr., Dos Estrellas Min. Co., P. O. Box 34, El Oro, Mex., Mexico.
ARCHBALD, JAMES, JR., Engr. and Agt., Girard Estate, 405 Thompson Bldg., Pottsville, Pa.
ARMSTEAD, DANIEL McP., Ingersoll-Rand Co., Farmers Bank Bldg., Pittsburg, Pa.
ARMSTEAD, HENRY, JR., Cons. Engr............Apartado 65, Guanajuato, Mexico.
ASTLEY, JOHN W................17 Manning Arcade Annex, Toronto, Ont., Canada.
BARRON, GEORGE D...P. O. Box 596, Rye, N. Y.
BELIN, HENRY, JR..................710 Traders National Bank Bldg., Scranton, Pa.
BELL, J. MACKINTOSH...Almonte, Ont., Canada.
BERG, HAAKON A.........................Asst. Supt., Carnegie Steel Co., Rankin, Pa.
BLAIR, ALLEN F.......................................805 Lowman Bldg., Seattle, Wash.
BLEECK, ALFRED W. G., Care The B. B. P. C. Co., Ltd., Yenangyoung, Upper Burma.
BLOW, A. A...Ware Neck P. O., Gloucester Co., Va.
BROMLY, ALFRED H., Care Taylor & Howat, Apartado 232, Mexico City, Mexico.
BROOKE, HENRY.....................Supt., Roanoke Coal & Coke Co., Worth, W. Va.

CARPENTER, ALVIN B.........................1015 California Bldg., Los Angeles, Cal.
CHANEY, R. GORDON, JR., Engr...........................Shirley Hotel, Denver, Colo.
CHASE, CLARENCE C...............................Apartado 12, Cananea, Son., Mexico.
CHRISTY, FRED C.........................Care Valley Bank of Phœnix, Phœnix, Ariz.
CROMWELL, ROBERT H............Teziutlan Copper Co., Aire Libre, Pue., Mexico.
CROWLEY, TIMOTHY I..Instructed to hold all mail.
DANIEL, WILLIAM B....................................2443 Woolsey St., Berkeley, Cal.
DEWEY, C. E........................ ....P. O. Box 607, Denver, Colo.
DIEFFENBACH, H. M................................Apartado 793, Mexico City, Mexico.
DIETZ, CARL F..8 Westland St., Worcester, Mass.
DIXON, JAMES T..............."Duasdale," Mulgrave Rd., Sutton, Surrey, England.
DRAPER, CARL H.............................Hotel Americano, Ameca, Jal., Mexico.
DRAPER, FRED W...Fayville, Mass.
EAGAN, CHARLES E., Min. Engr......................11 Broadway, New York, N. Y.
EDMONDSON, HORACE W., Rio Plata Mining Co., 809 Title Insurance Bldg., Los Angeles, Cal.
EDSALL, BURROUGHS..Benton, Mono Co., Cal.
EMERY, A. B..........................Harvard Club, 27 W. 44th St., New York, N. Y.
EVANS, HERBERT A., Care London & Pacific Petroleum Co., Negtitos, near Paita, Peru, So. America.
EWING, CHARLES G.......................................St. Regis Apts., St. Louis, Mo.
EYE, CLYDE M................................1012 Sahwatch St., Colorado Springs, Colo.
FEARN, PERCY LE R...................................17 Battery Pl., New York, N. Y.
FENNER, C. N...............................Geophysical Laboratory, Washington, D. C.
FENNER, CHARLES H...................619 Trust & Savings Bldg., Los Angeles, Cal.
FLAHERTY, ROBERT H., Mackenzie, Mann & Co., 9 Toronto St, Toronto, Ont., Can.
FINCH, H. WYNNE,............The Atheneum, Pall Mall, London, S. W., England.
FRANKE, RUDOLF, Met. Engr., Dir., Smelting Operations, Mansfeld Copper Mining & Smelting Co., Eisleben, Germany.
FRASCH, H...17 Battery Pl., New York, N. Y.
GIRAULT, EDMUNDO...................3a Calle Prim No. 56, Pachuca, Hid., Mexico.
GLOVER, GEORGE H., JR.........................701 Madison Ave., New York, N. Y.
GODSHALL, L. D...2892 Sunset Pl., Los Angeles, Cal.
GRANGER, HENRY G..................................Cartagena, Colombia, So. America.
GRIFFITH, WILLIAM V.......................................P. O. Box 100, Miami, Ariz.
HAAS, HERBERT.........MacNamara Mining Co., P. O. Drawer P, Tonopah, Nev.
HARDY, J. GORDON.......................................206 Mills Bldg., El Paso, Texas.
HASELTINE, RICHARD S...Coalinga, Cal.
HAWKINS, EDWIN N......................................406 Boston Bldg., Denver, Colo.
HILDRETH, THOMAS F., Mgr. of Mines, Davidson Ore Mining Co., Buffalo, N. Y.
HINDSHAW, HENRY H.............................254 Washington Ave., Alpena, Mich.
HOLMAN, F. C..558 Lincoln Ave., Palo Alto, Cal.
HOLTER, EDWIN O............................. ....52 Wall St., New York, N. Y.
HUTCHINSON, RAND B.......................................Toltec Club, El Paso, Texas.
IRWIN, FREDERIC................................ .. 2181 W. 30th St., Los Angeles, Cal.
JACKSON, FREDERICK H., Care Santa Rosa Min. Co., Apartado 12, Concepcion del Oro, Zac., Mexico.
JAQUES, W. H., Vice-Prest. and Genl. Mgr., United Telephone Co., Board of Trade Bldg., Boston, Mass.
JENKINS, FRANCIS..............................Bursar, Univ. of Idaho, Moscow, Idaho.
JENNINGS, SIDNEY J....................................44 E. 80th St., New York, N. Y.
JOHNSON, ALEXANDER T., Genl. Mgr., Yellow Pine Mining Co., Good Springs, Nev.
JOHNSON, EDWARD H., East Rand Prop. Mines, Ltd., Box 134, East Rand, Transvaal, So. Africa.
KEDZIE, GEORGE E., Min. Engr., Dir., Cia. Minera La Constancia, Esmeralda, via Sierra Mojada, Coah., Mexico.
KEENEY, ROBERT M...Somersville, Conn.
KELLER, ARTHUR H....Care L. Giesken & Co., Barranquilla, Colombia, So. Am.
KENNEDY, ARTHUR T.......Rep. Iron & Steel Co., 1006 E. 3d St., Duluth, Minn.
KENNEY, HENRY S........ ....Bushtick, via Bulawayo, Rhodesia, So. Africa.
KRUTTSCHNITT, JULIUS, Supt., Am. Smelt. & Refin. Co., Asientos, Aguas., Mexico.
LANDFIELD, JEROME B..............................Crocker Bldg., San Francisco, Cal.

LAWRENCE, WILLIS..........Hotel Victoria, San Francisco, Cal.
LEE, CHESTER F..........444 Henry Bldg., Seattle, Wash.
LINDSAY, LIONEL..........Crocker Bldg., San Francisco, Cal.
LINTON, RAYMOND A..........Saginaw, Mich.
LOCKE, AUGUSTUS..........Apartado 34, El Oro, Mex., Mexico
LONDON, CLARENCE J..........1813 N. Broad St., Philadelphia, Pa.
LUNDBOHM, HJALMAR..........P. O. Box 236, Stockholm, Sweden.
McNEILL, WALTER F., Secy.-Treas., Western Coal Operators Asso.,
301 Judge Travis Bldg., Calgary, Alta., Canada.
MACKILLIGIN, ALFRED M..........Hurstbourne Tarrant, Andover, Hants, England.
MALCOLMSON, JAMES W., Cons. Engr., Lucky Tiger-Combination G. M. Co.,
1012 Baltimore Ave., Kansas City, Mo.
MANN, WILLIAM S., Genl. Supt., Pilones Mining Co., La Portilla, Dur., Mexico.
MAYER, PAUL H..........169 N. Fulton Ave., Mt. Vernon, N. Y.
MEIN, WILLIAM W..........1043 Mills Bldg., San Francisco, Cal.
MILLER, JOSEPH......Supt., Long Tunnel Mining Co., Walhalla, Vic., Australia.
MORAN, ROBERT D..........519 California St., San Francisco, Cal.
MORRISON, WILLIAM J., Canada Foundry Co., Ltd.,
So. Porcupine, Ont., Canada.
MUNRO, DUNCAN M..........Apartado 37, Guanajuato, Mexico.
MYERS, JAMES W., Met. Supt., North American Smelting & Mines Co.,
Golden, Colo.
NACK, CHARLES..........Clifton Hotel, Clifton, Ariz.
OTAGAWA, MASAYUKI.......Genl. Mgr., Ashio Copper Mines, Shimotsuke, Japan.
PARKER, J. L., Min. Engr..........523 Pacific Bldg., Vancouver, B. C., Canada.
PARRY, CHARLES F., The Sub-Nigel, Ltd., Box 50, Nigel, Transvaal, So. Africa.
PARSONS, HORACE F..........The Dalles, Wasco Co., Ore.
PHILLIPS, WALTER I..........General Delivery, El Paso, Tex.
POILLON, HOWARD A..........Care C. Poillon, 99 John St., New York, N. Y.
POTTER, CHARLES F..........734 Title Insurance Bldg., Los Angeles, Cal.
PURDUE, ALBERT H.........State Geol., State Geological Survey, Nashville, Tenn.
PUTNAM, DANA G..........R. F. D. 1, Fallon, Nev.
REECE, FREDERICK B..........Instructed to hold all mail.
ROHLFING, D. P..........Farrell, via Mazuma, Nev.
ROTHSCHILD, CLARENCE G., Min. Engr. and Operator, 43 Leonard St.,
New York, N. Y.
RUETSCHI, RUDOLF..........P. O. Box 626, Hammond, Ind.
RUTLEDGE, JOHN J..........Bureau of Mines, 40th and Butler Sts., Pittsburg, Pa.
SANFORD, CHARD O..........Hotel Burlington, Los Angeles, Cal.
SAVAGE, ARTHUR E., Care E. L. Baillieu, 70 Cornhill, London, E. C., England.
SAXMAN, CHARLES W., Genl. Mgr., Copper Reef Cons. Mining Co.,
San Carlos, Ariz.
SCHIERTZ, FERDINAND A..........58 Cedar St., Roxbury, Mass.
SHALER, MILLARD K.....Care Forminière, Kinchasa, Congo Belge, West Africa.
SHANKS, DAVID W., Rio Plata Mining Co., 809 Title Insurance Bldg.,
Los Angeles, Cal.
SHIPP, ELLSWORTH M., Cons. Met. Engr..........2 Rector St., New York, N. Y.
SPENCE, HAROLD C. E..........West Merigonish, Pictou Co., N. S., Canada.
STANFORD, H. R........Bureau of Yards & Docks, Navy Dept., Washington, D. C.
STEVENS, BLAMEY..........422 Lippincott Ave., Riverton, N. J.
STEWART, ARTHUR J., Care C. Guzman, Calle de la Reforma No. 8,
Jalisco, Jal., Mexico.
STEWART, ROBERT H..........Trail, B. C., Canada.
STOLTZ, GUY C., Genl. Supt., Witherbee, Sherman & Co, Inc., Mineville, N. Y.
STUCKEY, LEONARD C..........Instructed to hold all mail.
THACHER, WILLIAM A..........Lake City, Hinsdale Co., Colo.
THOMAE, W. F. A., Care Pearse, Kingston & Browne, 8 Victoria Ave.,
Bishopsgate St., London, E. C., England.
THOMAS, EDWARD G..........700 Union Oil Bldg., Los Angeles, Cal.
TONNELE, THEODORE..........258 W. 70th St., New York, N. Y.
TURRELL, HAROLD, Care Charles Turrell, Royal Societies Club, St. James St.,
London, S. W., England.
VALENTINE, MALVERN R., Taylor & Brunton Ore Sampling Co.,
P. O. Box 281, Victor, Colo.
VIVIAN, GEORGE G..........Smelter Mgr., Pittsmont Smelter, Butte, Mont.

WAINEWRIGHT, WILFRID B........................Union Oil Bldg., Los Angeles, Cal.
WALKER, MYRON R..............................P. O. Box 278, La Salle, N. Y.
WATTERS, DANIEL M..........................2557 Eleventh Ave. W., Seattle, Wash.
WEBBER, GEORGE E...........Care G. A. Hare, 1569 Clay St., San Francisco, Cal.
WEEKES, FREDERIC R..............................71 Broadway, New York, N. Y.
WILDE, THOMAS B., Cons. Min. Engr., Prest., Modoc County Irrigation Co., 301 Columbia Trust Bldg., Los Angeles, Cal.
WILDING, JAMES, JR., Smelter Supt., Rio Tinto Copper Co., Terrazas (L. N. de M.), Chih., Mexico.
WILKINSON, CHARLES DALZELL, Min. Engr., 62 London Wall, London, E. C., England.
WINMILL, HALLETT, Mgr. Northern Nigeria (Bauchi) Tin Mines, Ltd., Care P. O., Naragata, Northern Nigeria, West Africa.
WOOD, LEE S..626 Tinken Bldg., San Diego, Cal.
WRIGHT, LOUIS A..813 Mills Bldg., El Paso, Tex.
YAMAGUCHI, KISABURO......................24 Hinokicho Akasakaku, Tokyo, Japan.
YATES, JAMES..602 Ninth St., Rock Springs, Wyo.
YOUNG, CLINTON M.......................................1227 Ohio St., Lawrence, Kan.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address of Record, from which Mail has been Returned.
Cook, Edward H.,	Minas Birimoa, S. A., Birimoa, via Canelas, Dur., Mexico.
Danforth, A. H.,	Cotopaxi, Colo.
Donnelly, Thomas F.,	Cia. Real del monte y Pachuca, Pachuca, Hid., Mexico.
Eatherly, Adrian D.,	Obey City Coal Co., Obey City, Tenn.
Edwards, Robert L.,	P. O. Box 1673, Salt Lake City, Utah.
Fitzgerald, Thomas F. M.,	211 Sharon Bldg., Salt Lake City, Utah.
Furness, James W.,	Coffee, Trinity Co., Cal.
Geiger, Arthur W.,	Cortez, via Beowawe, Nev.
Goodloe, Meade,	So. Ariz. Smelting Co., Sasco, Ariz.
Hagemann, Wilhelm,	Metates, via Tepehuanes, Dur., Mexico.
Hawkins, Tancred,	Red Bandana Gold Mine, Elizabethtown, N. M.
Hollis, R. W.,	Silverton, Colo.
Johnson, Dion L.,	325 Water St., Pittsburg, Pa.
Kimball, Edwin B.,	Alaska-Commercial Bldg., San Francisco, Cal.
Lampshire, John O.,	Vulture Mine, Wickenburg, Ariz.
Leavell, John H.,	Buffalo Mine, Cobalt, Ont., Canada.
Le Noir, Frank H.,	Box 16, Mt. Bullion, Cal.
Levensaler, Lewis A.,	Cordova, Alaska.
McDougall, Wallace D.,	20 Bedford Place, Russell Sq., London, Eng.
McPherson, William B.,	415½ S. Spring St., Los Angeles, Cal.
Miller, Emory T.,	Minas "La Union," Miramar, Costa Rica, C.A.
Moore, Roy W.,	P. O. Box 48, Velasco, Tex.
Munroe, Martin,	Bengal Coal Co., Murulidih, Mohada, B. N. Ry., Bengal, India.
Nelson, D. W. C.,	Baker City, Ore.
Nobs, Frederick W.,	Negociacion Minera Santa Maria de Guadalupe y Anexas, S. A., Minillas, Zac., Mexico.
Pearson, William R.,	628 W. 114th St., New York, N. Y.
Perks, Harry B.,	419 Board of Trade Bldg., Portland, Ore.
Prentis, Edmund A., Jr.,	Lluvia Oro Mine, Lluvia de Oro, Chih., Mex.
Rathborne, Merwyn R. W.,	Amargosa, via Las Vegas, Nev.
Rhew, James W.,	Cia. Minera y Exploradora de Ventanas, S. A., Ventanas, Dur., Mex.
Sheldon, Waldo,	Urique, Chih., Mexico.
Short, Frank R.,	Carson City, Nev.
Thornton, Edward T.,	Apartado 30, Matehuala, S. L. P., Mexico.
Twynam, Henry,	O. K. Copper Mine, Cairns, No. Queensland, Australia.
Watson, Ralph W.,	Calloo, Utah, Clifton Mail box.
Weddle, Joseph H.,	100 William St., New York, N. Y.

NECROLOGY.

The deaths of the following members were reported to the Secretary's office during the month of February, 1912:

Date of Election.	Name.	Date of Decease.
1902.	**Buckley, Ernest R.,	January 19, 1912.
1897.	*Fleming, John B.,	December 17, 1911.
1889.	*Grant, James B.,	November 1, 1911.
1906.	*Kane, Daniel B.,	January 3, 1912.
1871.	*Smith, T. Guilford,	February 20, 1912.

BIOGRAPHICAL NOTICES.

Horace H. Emrich was born Oct. 11, 1880, in New York City, but his family removed to Colorado in 1889, and he was educated in that State, in which his uncle, Mr. Anton Eilers, was a recognized leader in the metallurgical industry. Under the advice of Mr. Eilers, he entered the School of Mines at Golden, Colo., from which he was graduated in 1903. During his vacations, he spent much time at the Colorado smelting-works directed by his uncle—an establishment to which many of the leading American metallurgists of this generation owe the training which insured their subsequent success—and, as an officer of the Colorado Smelting Co., a frequent visitor at its works in Pueblo, Colo., and a life-long friend of their director, I can bear witness that the character and conduct of young Emrich, as shown during the period of his technical education, gave the highest promise of a future honorable and useful professional career. At the same time, he was one of the most popular students at Golden, a "star player" at base-ball and foot-ball, and an active participant in all college affairs. After his graduation, he worked for about six months at the Colorado smelter, and then (doubtless under the wise advice of his uncle) accepted employment at the Perth Amboy refinery of the American Smelting & Refining Co., where he began, in the autumn of 1903, practically at the bottom, as shift-boss in the department of the electrolytic refining of copper. His ability and fidelity rapidly won deserved recognition; and he was promoted to the position of Assistant Superintendent, and finally to that of Superintendent, which he held from 1908 to early in 1910. His technical success in this department is evidenced by the brilliant and suggestive paper from his pen, The Refining of Copper, presented at the New York meeting of February, 1912, and also by the circumstance that, in 1910, he was called to be superintendent of the electrolytic refinery of the Kyshtim Corporation, Ltd., in Perm, Russia—an enterprise conducted by English capitalists, who selected him on the strength of his high professional record. The duties of this new position he discharged with conspicuous ability, and with a loyalty which probably cost him his life. For, on the evening of Oct. 17, 1911, he was killed by a shot fired through the window of his residence. According to the latest intelligence, the crime was perpetrated in individual revenge for his dismissal of a thieving employee. Since Mr. Emrich was universally popular with his associates and workmen, as well as his employers,

* Member. ** Life Member.

there seems to be no other explanation. Indeed, I understand that the Russian authorities have already arrested a man, whose previous history favors this hypothesis.

Whatever its cause, Mr. Emrich's sudden death, at the age of 31, has cut short a career of great usefulness and high promise, and constitutes one of the saddest among the many tragic stories which it has been my duty, as official chronicler of the Institute, to place upon record. It is made doubly pathetic for me by the circumstance that I had to present at the recent New York meeting of the Institute, a paper of Mr. Emrich, the manuscript of which was received five days after the announcement, by cable-dispatch, of his sudden death. R. W. R.

Harry Robert Hall was born Jan. 16, 1868, at Mogadore, Ohio, and was graduated from the Ohio State University as Engineer of Mines in 1889. Having devoted special attention to analytical chemistry, be engaged himself upon graduation as chemist of the Carbon Iron & Steel Co., at Parryville, Pa. In 1891, he became chief chemist of the Crane Iron Works, at Catasauqua, Pa., but returned in 1892 to the Carbon Iron & Steel Co., as Superintendent—a position which he held until 1898, when the works were closed by reason of the depression of business. For a brief period, he had charge of the furnaces of the Va. Iron, Coal & Coke Co., at Middlesboro, Ky.; and later in 1899 he became Assistant General Manager of the Dunbar Furnace Co., at Dunbar, Pa. Two years later, he became connected as engineer with the Wellman-Seaver-Morgan Co., of Cleveland, O., and, soon after (1902–3) was Superintendent of the blast-furnaces of the Algoma Steel Co., at the Sault Ste. Marie, Lake Superior. In 1904–5 he was furnace-manager, at Standish, N. Y., for the Delaware & Hudson Co., and in February, 1906, he became Superintendent of the Crane Iron Works, Catasauqua, Pa., which position he held at the time of his death, which took place Dec. 10, 1911, in the German hospital at Philadelphia, after a surgical operation.

Mr. Hall became a member of the Institute in 1891, while he was chemist of the works of which he was afterwards Superintendent. He was highly esteemed by his employers and workmen, and by the citizens of Catasauqua. He was a leader in religious and charitable work; and his death in his forty-fourth year is a lamentable loss to his profession and to the world.

Washington Jones was born Feb. 22, 1822 (the birth-day of George Washington, 90 years before), and doubtless received his name by reason of this coincidence, together with the circumstance that his grandfather had been an officer in the Continental army. After preliminary education in common school, and under private tutors, he became, in 1839, apprentice to Merrick & Towne, operating the Southwark foundry and machine-shop, whom he served for six years as machinist and draftsman. At the end of that period, feeling the necessity of additional professional knowledge, he took (without completely interrupting his occupation) a two years' course in higher mathematics, mechanical drawing, etc., which qualified him for further promotion. In 1849, he became chief draftsman of the Penn Works of Reancy, Neafie & Co., builders

of marine engines, with which firm he remained until the end of 1855. Early in 1856, he became, and remained until April, 1862, General Superintendent and constructing engineer of the Port Richmond iron-works, of I. P. Morris & Co. It is a significant indication of Mr. Jones's record that his services seem to have been desired by those who had already employed him. Thus, in 1862, he returned as Assistant Superintendent to the Southwark foundry, where he had begun as apprentice 23 years before; and in 1866 he resumed at the Port Richmond iron-works the position of general superintendent, which he retained until the works were sold to Cramp & Sons in 1891. After that, he retired from active professional labors, except as consulting mechanical engineer, continuing to reside in Philadelphia. He died July 30, 1910.

Mr. Jones was elected a member of the Institute in 1881, and became at once a life-member. He was also a member of the American Society of Civil Engineers, the American Society of Mechanical Engineers (of which he was a Manager in 1880–81, and Vice-President in 1881–82), the Franklin Institute (of which he was Vice-President in 1905), the Engineers' Club of Philadelphia (of which he was at one time President), etc., and a director of the American Dredging Co.

Thomas D. Murphy was born Sept. 12, 1867, in Lanark county, Ontario, Canada. In 1893, he was employed in underground work (and also as assayer) at various silver-lead mines of the Neihart district, Montana. When the Neihart mines were shut down, by reason of the low price of silver, Mr. Robert M. Raymond, the Manager of one of the Neihart groups, having been appointed Manager of the Harquahala mines in Arizona, offered him a place there. The Harquahala property was already known to be on the verge of exhaustion; and the problem presented to Mr. Raymond's management was that of thorough, intelligent and economical salvage. This involved difficult and varied work in exploration and exploitation, the utilization of low-grade ores and tailings, and the realization of all possible assets. In this work Mr. Murphy loyally assisted his chief with credit to himself, and not without advantage in personal experience, acting at various times as custodian of materials, assistant accountant, assistant surveyor, assistant assayer, assayer, cyanide-foreman, cyanide-superintendent, and Assistant Manager. Finally, when Mr. Raymond was called to West Australia by the company, Mr. Murphy served during his absence as acting Manager, from December, 1895, to January, 1899. In 1896 he became a member of the Institute.

Robert M. Raymond himself had begun his career by practical experience as an employee at a mine, and had continued it by a course of technical study, qualifying him for further professional advancement. I cannot but believe that he advised his young, loyal, and intelligent assistant to follow a similar course. At all events, Mr. Murphy, when his work at Harquahala was done, spent his savings in a course of study at the University of California, where he went, between January, 1899, and June, 1901, through the principal work of the last two years of the mining curriculum, in chemistry, metallurgy, surveying, mineralogy, geology, mechanics, electricity, etc. Reinforced with this theoretical knowledge (all the

more highly valued and thoroughly digested because of the previous practice which had led him to long for it) he resumed his work. In 1901, he was temporarily employed in mines in the Cripple Creek district, Colo., the Tintic district, Utah, and the Eureka district, Nevada. Thence he went to the copper-mines of Cananea, Sonora, and to mines in the State of Chihuahua. In July, 1902, his former chief, Mr. Raymond, called him to El Oro, Mexico, where he served for more than two years as Secretary of the El Oro Mining & Railway Co., Ltd., in charge of correspondence, statistics, etc., besides conducting operations in mine-sampling, and examinations of prospects. From November, 1904, to February, 1905, as shift-boss of the El Oro mine, he utilized more directly his underground experience. The letter addressed to him by Mr. Raymond, when he resigned this position to accept the position mentioned below, attests the high estimate of his services entertained by that veteran mine-manager.

From February to September, 1805, Mr. Murphy, as Assistant Manager of the Guanajuato Reduction & Mines Co., had charge of the unwatering and development of a large group of old mines, and partial supervision of all other work, including the construction of an 80-stamp mill and a cyanide-plant. When, in September, 1905, he was recalled to El Oro, for service in the mill- and cyanide-department there, he received from the President of the Guanajuato Co. a letter, bearing witness to the value of his services.

In March, 1906, Mr. Murphy resigned his position at El Oro, to become manager of the Negociacion Minera de Maconi, in the State of Queretaro, Mex. The work of this position, and other work in various parts of Mexico, occupied him until about July, 1910, when he became General Manager of El Favor Mining Co., an American corporation, operating mines at Hostotipaquillo, Jalisco, Mex. While occupying this position, he was shot and killed, April 3, 1911, by a drunken Mexican miner—cut off, in his young prime, at the age of 44 years. Alas! how many such tragedies I am called to record!

R. W. R.

John O. Norbom was born Sept. 12, 1865, in Norway, where he received his professional education at the Technical School of Horten. In 1887, after some experience in copper-mining, he came to California, where he served as mining engineer at the Union Iron Works, San Francisco, and also as consulting engineer to various mining companies. He was also, for a time, Manager of the British Columbia iron-works at Vancouver. In 1900, he went to South Africa, where he was consulting mechanical engineer of the East Rand Proprietary Mines, at Johannesburg. Returning to California in 1909, he established himself as a consulting mining engineer. residing at Berkeley. It was at this time that he became a member of the Institute, which might have derived much benefit from his varied experience. But his life was suddenly ended Jan. 13, 1911, by an accidental explosion.

Joseph Squire was born Nov. 24, 1829 at Rochdale, Lancashire, England. Up to his 17th year, he attended excellent schools in his native town. From 1846 to 1849, he worked in underground surveying and mining in the Wigan coal-field, and at the "carding-

machines" of Manchester. Having come to the United States, he served as an apprentice in 1850 and 1851 at the Peabody furnace, Providence, R. I. From 1852 to 1858 he was engaged in exploring coal-lands and mining coal for sale in the Western and Southwestern States. In 1859, he became Superintendent and mining engineer of the Montevallo coal-mines in Alabama, and held that position until 1866. In 1866 and 1877, he was occupied with mineral surveys in western Alabama. In 1878, he located for the Pratt Co. the original Pratt coal-mines, afterwards acquired by the Tennessee C. & I. Co. Soon after, he commenced his work for the State Geological Survey on the Warrior coal-field, and subsequently prepared the report on the Cahaba coal-field which was published under his name. For five years he was the mining engineer of the Southern Railway Co.; but for some years preceding his death, Oct. 14, 1911, he was prevented by physical disabilities from active work.

Mr. Squire was one of the earliest members of the Institute, which he joined in 1871, the year of its foundation.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Present-Day Problems in California Gold-Dredging.

BY CHARLES JANIN, SAN FRANCISCO, CAL.

(San Francisco Meeting. October, 1911.)

THE first successful bucket-elevator dredge to operate in California was put in commission at Oroville in March, 1898. There had been numerous previous attempts at dredging, but none of the earlier boats proved a success. The gold-miners in California early conceived the idea of a machine to dig gravel from the beds and bars of auriferous streams that were inaccessible by the methods then employed, and it was only a few months after the discovery of gold in California that such a machine was shipped around Cape Horn from New York to San Francisco. This was, however, but the forerunner of many failures in gold-dredging, and was soon at the bottom of the Sacramento river. During succeeding years many other unsuccessful attempts were made, and it was not until 1897 that a dredge of the single-lift bucket-elevator type was floated on the Yuba river. This dredge was built by the Risdon Iron Works for R. H. Postlethwaite, and would probably have been a success if it had been operated on some of the rich Oroville ground instead of in a turbulent stream, where the dredge was wrecked during a flood, and was not repaired.

Fig. 1 is a sketch-map of California, showing gold-dredging areas.

It is not my intention to narrate in detail the history of the early failures in gold-dredging, and the various steps in the development of the modern boat, but merely to touch upon this in a general way, and to call attention to the wide difference in capacity and operating-cost between the first successful dredge, with an actual capacity of 600 cu. yd. per day—though its rated capacity was in excess of this—and the present modern dredge with 15-cu. ft. buckets, and an average capacity of 250,000 cu. yd. per month. Even this enormous capacity has several times been exceeded on monthly runs. The first successful dredges

in California were equipped with open-connected buckets, were operated on head-lines, and had short-tray tailings-stackers. For a number of years dredges of this type were used with varying success, generally on shallow and easily-dug gravel. When attempts were made to work deeper ground and cemented gravel had to be handled, it was found that these first boats were too light, and it was necessary to install heavier machinery to withstand the increased strain.

The modern California-type dredge, with close-connected buckets, spuds, and belt-conveyor for stacking tailings, was a gradual development through years of experimenting. This dredge embodies the ideas of successful operators, and it is generally conceded that dredge-construction and operating-methods in California are far ahead of those in any other country in the world. The dredges built in California cost from $25,000 to $265,000 each; a standard 8.5-cu. ft. boat costing from $150,000 to $175,000, according to conditions to be met in operation. With great improvements made in dredge-construction, and corresponding reduction in operating-costs, areas that were at first considered too low grade to be equipped with a dredge are being profitably worked, and the gold-production from this source, according to the U. S. Geological Survey reports, increased from $18,847 in 1898 to $7,550,254 in 1910, being 28.3 per cent. of the total gold-production of the State from all sources for the last year, and 84.9 per cent. of the total placer-gold for the year. The production by dredging during 1911 is estimated, as closely as can be figured at this date, at $8,000,000. Table I. shows the production by years of gold won from dredging-operations in California from 1898 to 1911, being a total of over $40,000,000.

TABLE I.—*Production by Dredges of Gold in California, Years 1898 to 1910.*

Year.	Amount.	Year.	Amount.
1898,	$18,847	1905,	$3,276,141
1899,	133,812	1906,	5,098,354
1900,	200,369	1907,	5,065,437
1901,	471,934	1908,	6,536,089
1902,	801,295	1909,	7,382,950
1903,	1,488,556	1910,	7,550,254
1904,	2,187,038	1911,[a]	8,000,000

[a] Estimated.

California dredges vary in size from 3.5- to 15-cu. ft. buckets. In Alaska some dredges are equipped with buckets as small as 1.25 cu. ft. to dig shallow ground, and are reported to be working profitably. A 15-ft. Marion dredge has recently been installed on the Boyle concession in Yukon Territory. The successful operation of this boat will no doubt encourage and be followed by further installations of the larger-sized boats where conditions warrant in the Far North. While electricity is the ideal power for operating dredges, steam has been successfully used on a number of installations, and experience has proved the merits of the gasoline- and distillate-engine for this work. There seems little doubt but that the successful development of the gas-producer for the generating of electric power will prove an important factor in considering future dredging of gravel-areas in districts where electric power or water-power for the installation of hydro-electric plants is not at present available. While it is unnecessary to go into the details of dredge-construction in this article, a short description of one of the modern dredges may be profitably given here. A fuller description of a dredge of this character has been published,[1] also a complete record of dredges constructed in California,[2] written by W. B. Winston and Charles Janin.

Yuba No. 13, one of the largest gold-dredges operating in California, was put in commission at Hammonton, in Yuba River basin, Aug. 10, 1911. This dredge, Fig. 2, was built by the Yuba Construction Co., and is one of five practically similar dredges built by the same company this year. It required 820,000 ft. of lumber for the hull and housing the hull; its dimensions are 150 by 58.5 by 12.5 ft., with an overhang of 5 ft. on each side, making 68.5 ft. total width of housing. The digging-ladder is of plate-girder construction and designed to dig 65 ft. below water-level, and is equipped with ninety 15-cu. ft. buckets arranged in a close-connected line. The entire weight of the digging-ladder and bucket-line is approximately 700,000 lb. The washing-screen is of the revolving type, roller-driven, and is 9 ft. in diameter by 50.5 ft. long and weighs 111,721 lb. Two steel spuds are used, each weighing over 44 tons. The ladder-hoist winch has a double drum, and weighs

[1] *Mining and Scientific Press*, vol. ciii., No. 15, p. 446 (Oct. 7, 1911).

[2] Gold Dredging in California, *Bulletin No.* 57, *California State Mining Bureau*.

67,016 lb. The swinging-winch consists of eight drums, and weighs 34,193 lb. The stacker-hoist winch weighs 3,732 lb. The gold-saving tables are of the double-bank type and have an approximate riffle-area of 8,000 sq. ft. The tailings-sluices at the stern can be arranged to discharge the sand from the tables either close to the dredge or at some distance behind. The conveyor stacker-belt is 42 in. wide and 275 ft. long, on a stacker-ladder of the lattice-girder type, 142 ft. long. Nine motors are in use on the dredge, with a total rated capacity of 1,072 h-p. The total weight of hull and equipment is 4,640,862 pounds.

Natoma No. 10 dredge, now under construction, is equipped with 15-cu. ft. buckets, and will have a steel hull, being the first dredge operating on a steel hull in California. The hull will be 150 by 56 by 10.5 ft. and will have a total weight of 920,000 lb. This will be about one-half the weight of a wooden hull to carry the same machinery, and the draft of the boat will be considerably lighter. This boat will be in operation in April, 1912.

Owing to the financial success of gold-dredging, most of the gravel-areas of California have been explored. It is hardly to be expected that any new fields as rich as those now being worked will be found, but it is possible that areas considered unprofitable for dredging, even within recent years, will be worked in the future.

Table II. gives in a general way the approximate extent of dredging-ground in the best-known dredging-districts in California, the average depth of gravel, and the value per cubic yard. Much of this ground has already been dredged, and some areas of lower-grade gravels which ultimately may be dredged are not included.

TABLE II.—*Dredging-Ground in California.*

Counties.	Total Proved Dredging-Ground.	Average Depth of Ground.	Average Value Per Cubic Yard.
	Acres.	Feet.	Cents.
Butte	6,600	30	15
Yuba	3,600	65	15
Placer	430	38	8
Sacramento	6,000	35	11
Calaveras	850	18	14
Stanislaus	200	22	14
Merced	400	20	13
Shasta	600	22	11
Siskiyou	350	35	14
Trinity	600	25	15

FIG. 1.—SKETCH-MAP OF CALIFORNIA, SHOWING GOLD-DREDGING AREAS.

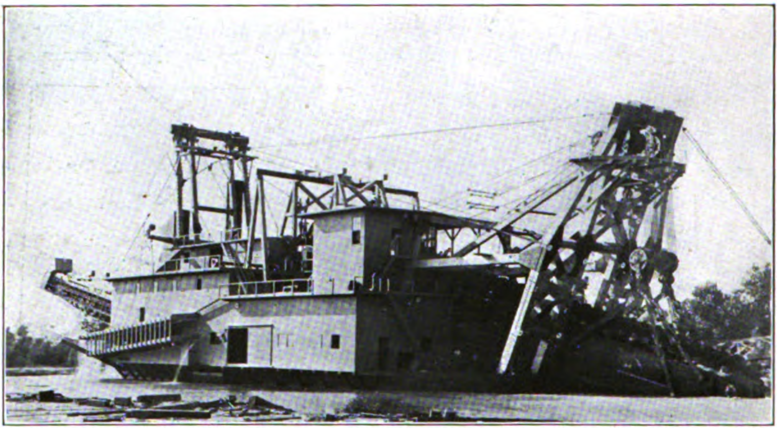


FIG. 2.—YUBA NO. 13, A 15-CU. FT. DREDGE.

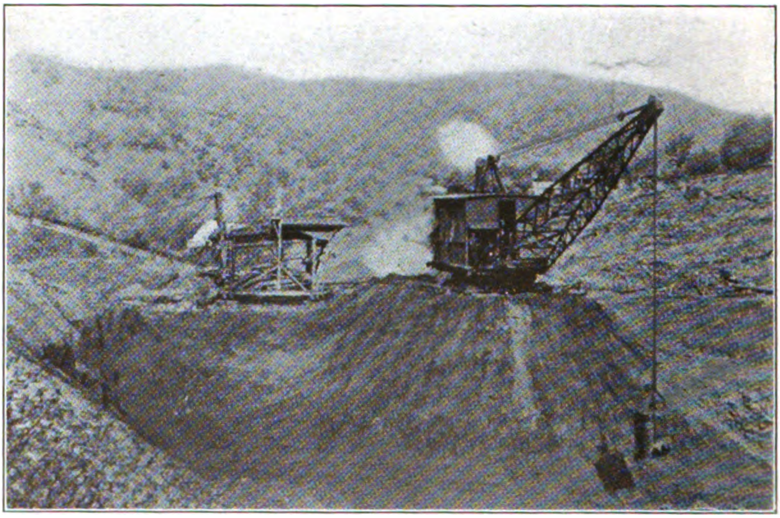


FIG. 3.—BUCKET-SCRAPER PLANT AT WORK.

FIG. 4.—3.5-FT. RISDON DREDGE OPERATING IN THE AMERICAN RIVER.

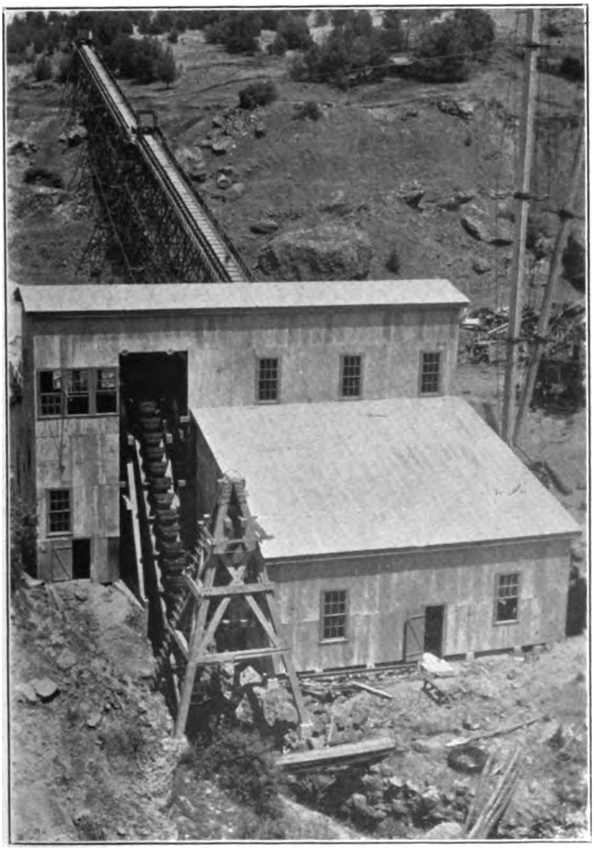


FIG. 5.—TARR GOLD-WASHING PLANT.

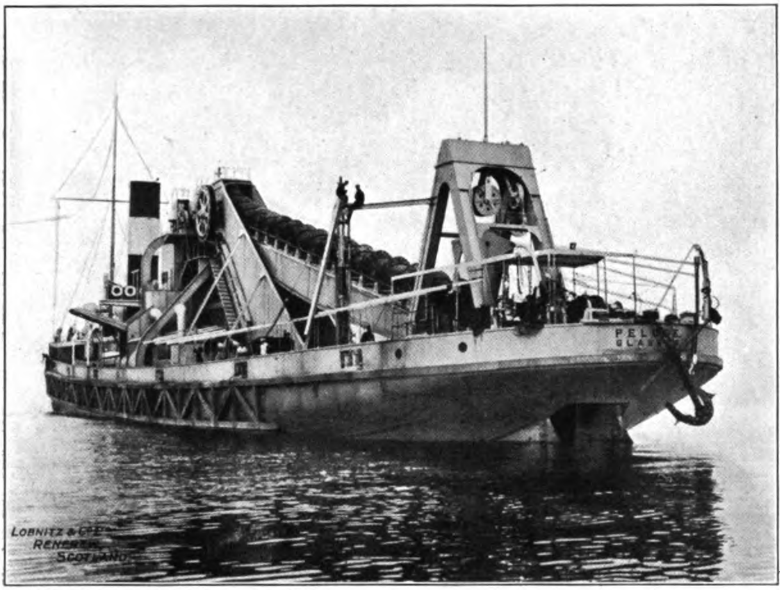


FIG. 6.—HARBOR-DREDGE; LARGEST BUCKET-DREDGE AFLOAT; 54-CU. FT. BUCKETS.

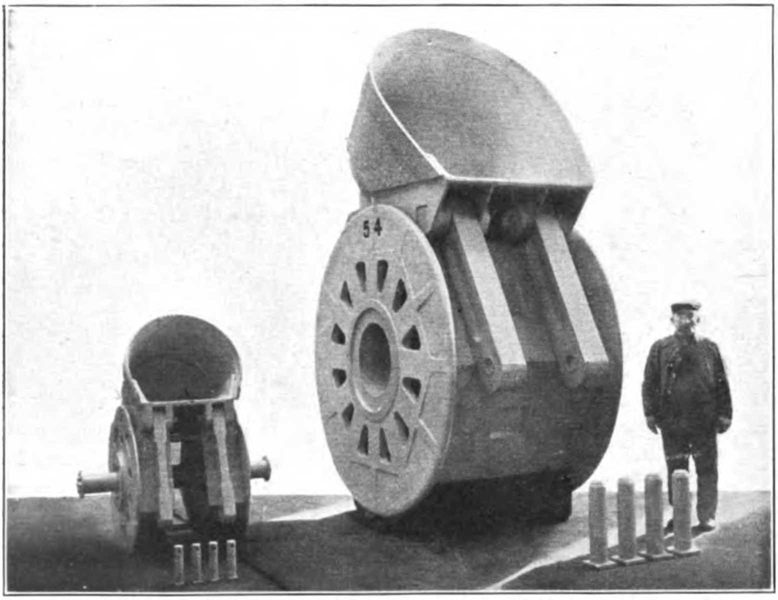


FIG. 7.—5-CU. FT. BUCKET AND TUMBLER COMPARED TO A 54-CU. FT. BUCKET FROM A HARBOR-DREDGE. (Lobnitz & Co., Renfrew, Scotland.)

In addition to the lower-grade gravel being worked in the future, areas considered too small for the profitable installation of an expensive modern dredge will be equipped with strong, lighter designed, and less expensive boats, and also with rebuilt dredges using machinery from dredges which have worked out the areas for which they were built, or that have been dismantled and replaced by larger boats. The machinery of some of these dismantled, and to be dismantled, dredges is in good condition, fit for many years of working-life, and can be refitted on a new hull on nearby property or properties not too difficult of access, and a practically new dredge built, in some cases at less than 50 per cent. of the cost of the original boat. It must be recognized that these rebuilt boats may not always be adapted to handle the gravel with as low operating-costs as might otherwise be attained, but the smaller expense of installation will prove a large factor in their selection and use. Dredges that were first constructed in Colorado, but proved unprofitable, were dismantled and their machinery used on hulls in California. The machinery from several California dredges has been moved to other fields, and, in some cases, to Alaska. Recent examples which may be mentioned are the Scott River dredge, formerly at Callahan, Siskiyou county, where it was unprofitable, which was dismantled and the machinery moved to Trinity Center, Trinity county. The Butte dredge, having worked out the company's holdings at Oroville, was also dismantled, and the machinery is being placed on a new hull near Jenny Lind, Calaveras county. The Scott River dredge was put in commission in August, 1908, and was equipped with 7.5-cu. ft. buckets. It was not quite two years in operation, being shut down May 30, 1910. It was purchased by the Alta Bert Gold Dredging Co., acting on the advice of H. G. Peake, and was moved to its ground in Trinity county. Estimated cost of building a new hull, installing the machinery on same, including a 28-mile haul, with a freight-cost of over 1 cent per pound, and building a power-transmission line of 5 miles, is $80,000. The Butte dredge was put in operation during November, 1902, and dismantled in July, 1910. It was equipped with 3.5-cu. ft. buckets. The machinery is being placed on a new hull, and includes a new bucket-line of 4-cu. ft. buckets. The cost of the installation,

including the new bucket-line, has been estimated at $30,000. The figures given for moving both of these boats must be considered approximations only, as they are not official.

There also seems to be a field in California and elsewhere for the installation of the bucket-scraper on auriferous areas too small or otherwise unsuitable for dredges, but of sufficient gold-content to be profitably handled by the scraper. This method of handling gravel is profitably in use in Siberia, in the Kolchan mines, at the present time, a plant built by the New York Engineering Co., having been installed by C. W. Purington. A view of a bucket-scraper plant is given in Fig. 3. In California one has been in successful operation near San Andreas. This machine rests upon rollers, by which it is moved on a plank track. It delivers to a set of trommels and gold-saving tables similar to those on a dredge. It has a 60-ft. boom upon which the scraper-bucket, weighing 1.5 tons and having a capacity of 1.5 cu. yd., works. The bucket is raised and lowered by means of a cable working over a sheave at the end of the boom, and is loaded by means of a drag-line traveling between sheaves in front of the floor-plate. Dumping is accomplished by means of an equalizing-cable attached to the drag-line and on the front of the bucket, which passes over a sheave fastened to the bucket-bale. The excavator is turned by a single-drum winding-engine, having two cables attached, whereby a complete circle can be made and the scraper-bucket operated on all sides. The machine is operated by steam-power, wood being used as fuel. Thus equipped, it has excavated gravel to a depth of 35 ft., and, it is claimed, can be worked to a depth of 50 feet.

The material is dumped by the bucket into a hopper 12 by 12 ft., which feeds a trommel-screen 4.5 by 22 ft., the upper part of which has $\frac{3}{8}$-in. perforations, the perforations of the lower 18 in. being 0.75 in. The oversize discharges to a belt-conveyor stacker, the undersize passes over Hungarian riffles, and then to a riffled sluice-box in which quicksilver is deposited, and finally to a 20-ft. sluice-way in which cocoa matting is used. Water is pumped into the hopper to wash the material through the cylinder. The cylinder and stacker are operated by a 15-h-p. electric motor, and the whole washing-apparatus is mounted on rails. It requires two men on the excavator and

one on the washer. Accurate figures of operating-costs are not at present available, but are understood to approximate 16 cents per cubic yard. At the Kolchan mines it is claimed that exclusive of management-charges, which are high, the cost of washing 24,400 cu. yd. for July was 14 cents per cubic yard. While these machines cannot be compared with modern dredges in capacity and operating-costs, it is claimed by those familiar with the operation that there is a good field under suitable conditions for their use in places where it is impracticable to install dredges.

The dipper-dredge has been successfully operated on small areas at Oroville and elsewhere, but does not meet with approval among dredge-operators in general, who contend that the efficiency of these boats, both as to yardage and gold-saving capacity, is not up to that of the standard type. These boats have a low first-cost (about $25,000, f.o.b. factory) and are built with buckets of from 1.25- to 2.5-cu. yd. capacity. It is claimed by the dealers and some operators that under the following conditions there is a field for this type of dredge: (1) where the ground is somewhat shallow; (2) where the extent of the ground is not sufficient to warrant the installation of a costly dredge; (3) where the material is of a rough character, boulders, and stumps; (4) where the ground is mixed with more or less clay, as the dipper will relieve itself notwithstanding the adhesiveness of the material.

The reported successful operation of a small Risdon dredge on the middle fork of the American river near Forest Hill, Placer county, under conditions thought by many to be impossible for operation, will undoubtedly encourage other installations in rivers at times torrential. A. A. Tregidgo is now promoting a company for the dredging of gravel some distance below this place. Without attempting to pass on the merits of either of these undertakings, it is interesting to consider them as engineering problems, and their success will draw considerable attention to similar gravel-areas in this State and elsewhere. While gold-dredging in California has been mainly confined to gravel-areas some distance from the main river-channels, it is claimed that a small boat, with some modifications in the hull to suit the river conditions, and adapted for work in a swift current, with head-line and mooring-winches of greatly increased

strength, can be profitably operated, even in the winter months, in the California rivers where not in conflict with the present débris laws. In addition to the use of a small dredge, it is proposed by Mr. Tregidgo to operate a hydraulic elevator on the same property, water being available at a head of 1,000 ft. This water will first be used at a head of 400 ft. to generate electric power to be transmitted to the dredge. From this point the water will have a head of 600 ft., to be used in the hydraulic elevator. In addition to these enterprises, there are several proposed dredge-installations on somewhat similar areas in this State, concerning which definite information is not available at present. Fig. 4 is a view of a 3.5-ft. Risdon dredge operating in the American river.

The suction-dredge has never been favorably considered in gold-dredging, except by the inventors and builders. It is claimed by those interested that one is in successful operation in Shasta county, and another in Siskiyou county, though other information is to the effect that these boats were not a financial success and are no longer operating.

A method closely allied to dredging, which may be termed a hybrid of dredge and hydraulic mining, is attracting much attention in California. This is the plant of the Tarr Mining Co. at Smartsville, which was built to operate the old Blue Gravel hydraulic mine. Fig. 5 is a view of the plant. This mine was a producer in early days, but was shut down by the Débris Commission. This company believes that it will be able to operate in compliance with the present law. From an engineering standpoint, the proposal has some interesting features. Briefly, it consists of hydraulicking the gravel-bank to a sump in front of a stationary dredge-building of concrete and sheet-iron, where a regular steel-girder dredge-ladder, equipped with fifty-two 7-cu. ft. buckets elevates the gravel to a trommel 45 by 6 ft. with 0.5-in. holes. From the screen the undersize flows to gold-saving tables with Hungarian riffles having an approximate area of 4,600 sq. ft. The oversize passes to a belt-conveyor 570 ft. long, built in two sections, each section being driven by a 50-h-p. motor. A 100-h-p. motor is used on the digging-ladder, and a 30-h-p. motor on the revolving-screen. At the end of the belt-conveyor stacker two Bleichert tramways are being con-

structed. These will afford a much larger dumping-ground for the tailing.

The fine material, after passing over the gold-saving tables, flows through a bed-rock tunnel about 0.5 mile long and is elevated to a concentrating-plant equipped with tables of the Overstrom type. The material first passes through revolving-screens, the oversize being carried outside the concentrator, and the undersize to the tables. It is the idea of the management that this plant will save black sand, which is claimed to be valuable, and any gold and platinum that escapes the first tables.

The concentrator stands several hundred feet from the Yuba river, and a concrete dam will be constructed to afford a settling-basin for the tailings. This experiment will be watched with interest. Its success will undoubtedly mean that other properties formerly worked as hydraulic mines, which have been shut down by the Débris Commission, will be operated on somewhat similar lines. The equipment of such a property is no small matter. The operating-cost as yet is purely speculative. The management of the Tarr company does not believe that the cost of operating the plant will exceed 8 cents per cubic yard.

On Bonanza creek, in the Yukon, a portable bucket-elevator arranged to elevate gold-bearing gravel to a system of portable sluices, the position of which can be changed when necessary to obtain a new dump, has been in more or less successful operation by the Yukon Gold Co. for a number of years, but only one attempt, so far as is known, has been made to adjust this method to California gravels. The mode of operation is as follows: A sump approximately 20 ft. square with a depth of from 14 to 16 ft. below bed-rock is excavated to receive the lower end of the elevator. A channel or bed-rock sluice emptying into the sump, with a grade of from 5 in. to 12 ft., is excavated in the bed-rock and provided with riffles. The gravel-bank to be treated is hydraulicked with two 3-in. giants, and a third giant sluices the gravel to the sump, from which the buckets elevate it to a riffled sluice about 25 ft. high. The elevator-ladder is equipped with buckets of 3 cu. ft. capacity, close-connected, and driven by a 50-h-p. motor. The water used in the upper sluice is pumped from the sump by one 12-in. centrifugal pump belted to a 100-h-p. motor, and one 8-in. pump driven by

a 50-h-p. motor. A derrick with a long boom is placed in a position convenient for handling any large boulders. Records of operating-cost have not been made public by the Yukon Gold Co., and it is understood that the use of these machines will be discontinued or considerable changes made in the method of operating them.

A somewhat similar machine was operated a few months during 1910 at Poker Bar, Trinity county. This was installed by R. E. Whitcomb, at a cost of approximately $15,000. The motive-power was steam, wood being used as fuel. The expenses of operation were great, but no accurate data are obtainable at present. It is said that the operation of the machinery thoroughly demonstrated the value of the gravel-area, and it is reported that a dredge will be installed this year. The management contemplates moving a Marion dipper-dredge, formerly successfully operated at Oroville, and which had turned over the holdings of the original company. It is estimated that this dredge can be put in operation at a cost of $15,000. At the present time there are 62 bucket-elevator dredges operating in California, and five under construction. Of the six dredges put in commission in 1911, four have been built by the Yuba Construction Co. and are equipped with Bucyrus machinery and 15-cu. ft. buckets, one was built by the Union Iron Works and equipped with 8.5-cu. ft. buckets, and one by the Risdon Iron Works with 4-cu. ft. buckets. One of those under construction has buckets of 15 cu. ft. capacity, one 7.5-, one 7-, one 5-, and one 4-cu. ft. buckets.

It is interesting to note that of the 62 dredges, which are operated by 28 companies, 30 are operated by three companies controlled by W. P. Hammon and associates, distributed among three counties, as follows: Butte county, 8; Yuba county, 13; Sacramento county, 9. It may here be mentioned that the great progress and improvement is due in a great measure to the enterprise and successful operations of Mr. Hammon and his associates. Couch dredge No. 1, the first successful bucket-elevator dredge put in commission in the State, was financed by Mr. Hammon and the late Thomas Couch, and it seems eminently fitting that Mr. Hammon should be the leading gold-dredging operator in California, and in control of the largest dredging companies in America.

What seems to be a record in dredge-construction and worthy of mention is the building of the dredge for the Julian Gold Mining & Dredging Co. on Osbourn creek, near Nome, Alaska. This dredge was constructed by the Union Construction Co., of San Francisco. The dredge was shipped from San Francisco on June 1, arriving at Nome June 13. On June 17 the company commenced hauling material, and on July 22 the dredge was completed and operations started. The dredge-hull is 30 by 60 by 6.5 ft. It is equipped with 34 open-connected 2.75-cu. ft. buckets, and is designed to dig 14 ft. below water-level. Power is furnished by gasoline-engines as follows: one 50-h-p. for digging-ladder, winches, and screen; one 30-h-p. for pump; one 7-h-p. for lighting apparatus; a total of 87 h-p. Distillate costs at Nome 21 cents per gallon. Operating-expenses at present range from $110 to $125 per day, and the capacity of the dredge is from 1,000 to 1,300 cu. yd. per day, indicating an operating-cost of from 10 to 11 cents per cubic yard, exclusive of repairs. The cost of the dredge complete and in operation was $45,000. The Union Construction Co. also built a similar dredge for dredging tin, near Cape York, this latter being the first tin-dredging operation to be carried on in America. Its future will be watched with interest and may be followed by further installations.

With the development of the gold-dredge to its present efficiency, the question is often raised as to when the limit in size for economic dredge-installation will be reached. Much depends upon the conditions met in operation. There is no question as to the mechanical possibility of larger buckets. In Boston harbor a bucket-elevator dredge equipped with buckets of 2 cu. yd. capacity has been successfully operating for some years on harbor-work, and on the Danube river in Germany a bucket-elevator dredge having 2.5-cu. yd. buckets is now in operation. Fig. 6 is a view of a harbor-dredge equipped with 2-yd. buckets, and a 5-ft. and a 54-ft. bucket are shown in Fig. 7. While the mechanical possibilities have thus been proved, to apply such radical changes in size to the gold-dredge of to-day would necessitate an entirely different arrangement of the gold-saving tables and would probably result in a general modification of the whole gravel-washing apparatus now in use. Even the most optimistic advocates for increasing the

size of the dredge-buckets would hesitate at recommending a 2-cu. yd. bucket, which is nearly four times the present size of the buckets on the largest gold-dredges in operation, but there are a number of engineers who believe that the bucket-elevator dredge with buckets having a capacity of 1 cu. yd. will be constructed before long. While a dredge of this character would necessarily be equipped with heavier machinery and a larger hull than those on the present 15-cu. ft. boats, it is, as before stated, quite possible that, with modifications of the washing-apparatus, the hull of the 1-cu. yd. dredge may not be proportionately larger. The present 15-cu. ft. boats have a hull 60 by 150 by 12.5 ft., with a deck overhang of 5 ft. on either side, making a total width of 70 ft. The gold-saving tables are of the double-bank type and have an approximate area of 7,000 to 8,000 sq. ft. Without some change in the washing-apparatus, it can readily be seen that 14,000 sq. ft. of table-area would either necessitate a hull of greatly increased size, or additional tiers of tables, for which an increased length of bucket-ladder would be required to elevate the gravel to the additional height, or a general change in the design of the boat. Practice has demonstrated that when digging free-washing gravel the table-area of the 15-ft. boats is considerably in excess of all requirements, and some operators contend that it would not be necessary to proportionally increase the table-area when buckets of 1 cu. yd. capacity are constructed.

There may be a field for dredges of this size, for instance, in the Oroville and Folsom fields, to re-dredge the tailings-piles left from the first dredging-operations. After many of the cobbles have been removed for the rock-crushing plants, the ground, if dredged, will, in many cases, yield a fair return. Especially would this be the case in the areas where the early dredges worked, as the gold-saving apparatus of the first successful dredges was not as efficient as that in present use.

In addition to the gold recovered from the gravel, the reclamation of the land for agricultural purposes might be a considerable factor in estimating the total profit to be won from the installation of a mammoth dredge for this class of work. The first dredges, in turning over the ground, necessarily deposit the top soil on the bottom, and the gravel and boulders from the tailings-stacker on top of this. After much of the coarser

gravel is removed for rock-crushing operations, with some such arrangement as that which is being tried out in New Zealand in re-soiling experiments, this soil now below the gravel could, in re-dredging, to a great extent be deposited on the top of the coarser material. In reclaiming the dredged land it is, no doubt, a matter worthy of consideration. In this connection it is interesting to note the successful experiments of the Natomas Consolidated and others in planting eucalyptus trees on dredged land after the larger gravel has been removed, no re-soiling being necessary. Any estimate of the operating-cost of a dredge of this character is, of course, pure speculation, but there seems every reason to expect that, under favorable conditions, or in re-dredging some of these previously-dredged areas, a very low operating-cost would be obtained.

The operating-cost of dredging is always a matter of interest, but working-costs cannot be fairly used in comparison unless uniform methods of determining them are employed, and also unless operating-conditions are somewhat similar. As in other branches of the mining industry, it may also be said that the apparent operating-cost is in a great measure a matter of book-keeping. As the time available for preparing this article was limited, it has been found impossible to prepare new data on working-costs of dredges in California, so I have utilized a table prepared last year by me (Table III.).[3] Under similar conditions, the operating-costs are practically the same. The new boats have not been working long enough to make any figures of operating-cost of much value, but it is understood that they will under the same conditions appreciably lower the costs obtained by the 13.5-ft. boat.

It is interesting to note the following average operating-cost per cubic yard of the large companies working in California during 1910. The Yuba Construction Co., for the year ended Feb. 28, 1911, handled 13,970,728 cu. yd. at a total cost of 5.67 cents per cubic yard. The Natomas Consolidated handled, for the year ended Dec. 31, 1910, a total of 15,989,525 cu. yd. at a total cost of 4.52 cents per cubic yard, and during the six months ended June 30, 1911, a total of 10,793,891 cu. yd. at a total operating-cost of 3.78 cents per cubic yard. This company

---

[3] *Mining and Scientific Press*, vol. ci., No. 5, p. 151 (July 30, 1910).

has put in commission during this year three dredges with buckets having a capacity of 15 cu. ft., one being in the Feather River division at Thermalito, and two in the Folsom division on Rebel hill. These two boats are now satisfactorily handling ground that for a long time was considered too difficult for economical dredging. The gravel is deeper and more compact than any other in the district, and dredge No. 8 is handling ground containing much stiff clay. The Oroville Dredging, Ltd., for the year ended July 31, 1910, handled 5,661,612 cu. yd. at a total cost of 5.05 cents per cubic yard.

TABLE III.—*Working-Costs of Gold-Dredging in California.*

Capacity of Buckets.	Time in Commission.	Working Period for Figures Given.	Actual Working-Time: Hours During Working Period.[a]	Quantity Handled.	Average Depth of Gravel.	Operating-Expenses, in Cts. Per Cubic Yard.							Remarks.
						Labor and Material.	Electric Power.	Water.	Repairs.	General.	Taxes and Insurance.	Total Expense.	
Cu. Ft.			Hrs.	Cu. Yd.	Ft.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	
3	......	1 yr.	2,809	173,655	27.0	2.77	0.90	0.14	4.15	0.78	0.49	9.23	Difficult digging.[g]
3	5 yr. 9 mo.	1 yr.	7,216	458,882	26.9	2.03	0.69	......	3.28	0.63	0.37	7.00	Working under favorable conditions.
3.5	7 yr.	1 yr.	......	395,316	35.0	2.83	1.53	0.228	1.74	1.32	......	7.67	
3.5	6 yr. 6 mo.	1 yr.	7,344	461,882	35.0	2.85	1.48	0.195	1.71	1.07	......	7.32	Compact gravel land subject to overflow.
4	9 yr.	1 yr.	7,057	484,387	20.6	1.83	0.89	0.31	2.58	0.65	0.26	6.52	Remodeled dredge, uneven bed-rock, in places shallow.
5	6 yr.	1 yr.	......	481,184	25.0	3.28	1.46	0.39	2.97	1.52	......	9.55	Difficult ground, in places cemented gravel.
5	2 yr. 5 mo.	1 yr.	......	635,146	27.0	3.14	1.45	......	2.40	1.28	0.41	8.70	Difficult ground.
5	2 yr.	1 yr.	......	582,891	30.0	3.28	2.02	0.32	2.59	1.37	1.00	9.60	Difficult digging.
5	5 yr. 6 mo.	1 yr.	7,344	615,009	25.0	3.06	1.42	0.29	3.06	1.14	......	8.98	Difficult digging.
5	4 yr. 6 mo.	1 yr.	......	812,355	36.0	2.30[b]	1.08	......	2.95	......	0.35	6.65	Medium gravel with considerable clay, much brush on top soil.
5	3 yr. 5 mo.	1 yr.	6,798	1,148,480	25.5	0.88	0.52	0.05	1.77	0.25	0.35	3.80	Loose gravel, heavy overburden of sandy loam.
5	2 yr. 5 mo.	1 yr.	6,790	1,148,802	29.9	0.82	0.49	0.03	1.89	0.25	0.16	3.64	Loose gravel, heavy overburden of sandy loam.
5	4 yr. 7 mo.	1 yr.	6,644	599,614	38.5	1.77	0.92	0.25	4.03[c]	0.47	0.23	7.67	Difficult digging, working against 20-ft. bank.
7	9 mo. 10 days.	1 yr.	5,088	838,885	35.0	1.19	0.69	......	1.22	0.26	0.17	3.53	Difficult digging, gravel coarse, partly cemented.[h]
7	1 yr.	1 yr.	6,313	1,114,605	27.6	1.21	0.62	0.03	1.81	0.29	0.11	4.07	Compact gravel.
7	3 yr. 9 mo.	1 yr.	6,390	1,033,694	26.5	1.08	0.64	0.14	2.69[d]	0.34	0.20	5.09	Compact gravel, heavy digging.
7	2 yr. 9 mo.	1 yr.	6,917	1,017,167	28.1	1.10	0.65	0.15	2.19[e]	0.28	0.14	4.51	Compact gravel, heavy digging.
7	3 yr.	1 yr.	6,352	935,322	33.4	1.26	0.85	0.06	3.06	0.31	0.34	5.88	Compact gravel.
7	3 yr.	1 yr.	6,700	1,194,146	27.5	1.05	0.58	......	2.78	0.32	0.37	5.10	Compact gravel.
7.5	2 yr. 11 mo.	2 yr. 11 mo.	13,464	3,458,229	27.9	0.27	0.41	......	1.50	0.24	0.24	4.42[f]	Medium compact bench gravel.
7.5	9 mo. 6 days.	9 mo. 6 days.	5,582	944,879	28.9	0.95	0.58	......	1.30	0.27	0.39	3.55	Medium compact gravel with heavy over-burden.
7.5	2 yr. 6 mo.	1 yr.	6,402	1,369,844	70.2	0.99	0.77	......	1.95	0.45	......	4.16	Medium gravel overlain with hydraulic tailings.
7.5	2 yr. 6 mo.	1 yr.	6,900	1,281,351	67.8	1.09	0.98	......	2.01	0.45	......	4.53	Medium gravel overlain with hydraulic tailings.
8	6 mo.	6 mo.	3,162	583,927	42.5	1.69	0.59	......	1.14	0.28	0.22	3.92	Light gravel, dredge working against 10-ft. bank.
8	4 mo. 8 days.	4 mo. 8 days.	2,369	626,624	24.0	Segre	gated	costs	not	given		2.47	
9	5 mo.	5 mo.	......	580,310	51.0	Segre	gated	costs	not	given		4.98	Cemented gravel, difficult digging, 20-ft. bank above water-level.
13.5	8 mo.	8 mo.	4,478	1,803,201	19.0	1.02	0.47	......	0.60	0.12	0.09	2.30	Fine gravel, easy digging.

a. Total possible time in year's work, 8,784 hours.
b. Including general expense, management, etc.
c. Heavy repair-cost due to new tumbler, conveyor-belt, repairs to digging-ladder, screens, etc.
d. Replacing tumbler-shafts, conveyor-belt, and new screen included in repairs.
e. New steel spud and screen in repairs.
f. Depreciation-charges included in total expense.
g. A 7-ft. dredge is now working this ground at a profit.
h. This dredge successfully replaced an open-connected bucket-dredge which could not handle ground at a profit.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Gold-Production in California.

BY CHARLES G. YALE,* SAN FRANCISCO, CAL.

(San Francisco Meeting, October, 1911.)

A FEW years ago somebody connected with one of those self-constituted bodies of unofficial character, like a Chamber of Commerce, Board of Trade, or State Development Board, started a catch-phrase referring to California as "The Land of Sunshine, Fruit, and Flowers," and the railroad magazines and folders keep it steadily in use, working day and night. Yet it altogether ignores the substance which brought the State into the Union, which peopled it, and which made it famous throughout the world. You ladies and gentlemen who have come from what we here call "the East," have in your own States, no matter which one, sunshine, fruit, and flowers. But your Eastern States, having these things as we do, have not the gold that we do. Therefore, the old designation of "The Golden State," applied to California, should be revived, as being the most distinctive term. It is worthy of remembrance, too, that during the dark days of the civil war this State handed over $172,000,000 in yellow gold, and saved the credit of the nation.

Gold-mining has been carried on in California since

"The days of old,
The days of gold,
The days of '49,"

and it still continues. Since that historic year, and up to the end of 1910, the State has produced, in gold alone, $1,530,214,468. Since 1792 the entire United States production of gold has been $3,261,573,500, so that the single State of California has, in that period, produced within $201,144,564 of one-half of all the gold from Alaska, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Washington, and the Southern and scattering States. In other words, all the other 25 gold-producing States of the United States combined

* Statistician of the U. S. Geological Survey.

have only produced about two hundred millions more than the single State of California has in the long period of 118 years. Moreover, it has taken California but 62 years to produce that near half, which it has done at the average rate of $24,680,878 per annum. This shows an average gold-yield of $2,056,739 per month for the last 62 years.

California therefore deserves the title of "The Golden State."

It is to be noted, moreover, that California is still the leading gold-producer among the States of the Union, and there are still a larger number of producing gold-mines here than in any other State. Gold is being mined in larger or smaller quantities in 34 of the counties of the State.

Among other mining States of the Union, California has, as a gold-producing region, the distinction of holding the record on all counts. It has made by far the largest aggregate product; made the largest output in any single year; made the highest annual average, although its mines have been worked for more than 62 years; kept the lead as a gold-producer the greatest consecutive number of years; has the largest number of individual gold-mines; pursues the greatest number of varied branches of gold-mining; and has the widest geographical distribution of its gold-deposits.

The gold-belt of the State extends its extreme length from Oregon on the north to Arizona and Mexico on the south. Gold is mined in the highest parts of the Sierra Nevada mountains, the foot-hills, the valleys, and on the beaches bordering the ocean. The gold is taken from quartz, placers, pockets, seam-diggings, hydraulic drift, ocean-beach sand, by dredging, wing-damming, dry-washing, and other forms of mining. The snowy ranges, the river-beds, the beaches, the desert sands, the ancient buried rivers, the superficial gravel-deposits, all yield their quota. The climatic conditions in all except the higher ranges are favorable to work the year round. In some of the foot-hill counties, the men work their orange- or olive-orchards and vineyards in the summer and drift for gold under them in the winter months. It is to be noted that to-day the three great dredging-fields are at points where citrus fruits first ripen. The county producing the most gold is in the valley, below the foot-hills, and not in the snowy mountains.

It is not my intention to read you a statistical paper or bore you with a lot of figures, but rather to convey an idea of the present condition of the gold-mining industry in the State as far as it may be done briefly. A few figures are, however, necessary. It may be said that the record year of gold-production in California was 1852, when the placer-miners produced gold to the value of $81,294,700. In 1883 the yield was $24,316,873, and then the annual product gradually declined, owing largely to the closing of hydraulic mines, until, in 1889, the output was only $11,212,413. For seven of those years, between 1883 and 1904, it was less than $13,000,000 annually. Since 1904, the gold-yield has averaged about $19,000,000, sometimes exceeding $20,000,000, and it is to be confessed there is not much prospect of an increase. With labor at $3 per day, and an 8-hr. day enforced by law, it is difficult for the quartz-miners to make much profit on ore of ordinary grade unless large ore-bodies are worked, and as a consequence many have been compelled to cease operations. Still, the tonnage from the deep mines continues to be of considerable proportions, this having been 2,697,885 tons last year, of which 1,963,296 tons were siliceous or gold-ores. The average value in gold of this ore was $5.20 per ton. In some counties, where the veins are comparatively small, the values run up to $8 per ton. Taking a typical large mine in one of these counties, where nearly 100,000 tons were milled, the average yield per ton was $13.68, and the profit $7.51 per ton, over all costs of operation and development.

In the Mother Lode counties, where the ore-bodies are very wide, the ore is low grade. In one of these counties last year, 547,873 tons of ore were milled, yielding an average of $4.69 per ton. But taking all five of the Mother Lode counties, where 1,170,497 tons were milled, the average yield per ton was only $3.78.

It may be a surprise to some to know that, contrary to general supposition, the placer-mines of the State are now yielding 45.09 per cent. and the deep or quartz-mines producing 54.91 per cent. of the entire gold-product. About this proportion has prevailed for several years. It is true that the ordinary surface-placers, where they use rocker, tom, and sluice, now cut but a small figure, but the drift- and hydraulic mines are still

yielding, and the dredgers are now producing 84.94 per cent. of all the placer-gold. This comparatively new system of surface-mining has given renewed life to placer-work. Owing to adverse legislation, the hydraulic mines, formerly highly productive, are now yielding only 7.15 per cent., the drift-mines 5.82 per cent., and the surface- or sluicing-mines only 2.09 per cent. of the placer-gold. Since 1899 the dredges have dug out $40,318,775, and are now producing at the rate of $7,550,000 per annum, with 71 machines in operation. The details of this dredging-work will be given in the paper, Present-Day Problems in California Gold-Dredging, by Mr. Janin, presented at this meeting.

The largest production of gold in California last year came from Yuba county, mainly from dredging. The most productive in gold from deep mines is Amador, one of the Mother Lode counties. The leading hydraulic-mining county is Trinity, and the leading drift-mining county is Placer. The largest production from dredge-mines was from Yuba county.

It is to be confessed that little progress is being shown in the deep mining for gold, or even in the placer fields, aside from dredging-operations. Even in the latter, in the Oroville field, a decrease in gold-output is already apparent, owing to some of the ground having been worked out, but the increased output of the Yuba field, and in outside districts, made up for the loss in the Oroville dredging-field. There are only three large dredging-fields in the State, these being at points where the Feather, American, and Yuba rivers leave the foot-hills to enter the valley-lands, after, in their course, having cut through beds of auriferous gravel and depositing the fine gold with the soil carried down, when the streams are suddenly arrested from their swift flow by reaching level ground. There are numerous isolated points, however, in other counties, where the circumstances permit the operation of one or more dredges within restricted areas. For this reason dredging is being carried on in 10 counties of the State.

The speculative era of gold-mining has almost entirely disappeared from California. The stock of no single gold-mine is listed on the Stock and Exchange boards or publicly dealt in. The mining-work is now almost entirely carried on by organized companies which provide capital for the enterprise. The day

of the nomadic miner is virtually at an end, and the men are now nearly all employed at daily wages. Of course, there are still many prospectors, but most of the miners live in permanent thriving towns near the larger properties, far different from the old-fashioned primitive mining-camp. High-priced officials have been replaced, office-force and expenses reduced, and only skilled men employed. More railroads, better wagon-roads, cheaper supplies, improved methods of transportation, better machinery at lower cost, highly improved reduction-methods and appliances, adoption of proved modern processes, careful saving of concentrates, stronger powder, power-drills, electric and water-power, heavier and larger milling-plants, more extensive development, and generally improved systems and appliances, have all contributed in recent years towards a change for the better in gold-mining in California.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

A Modification of the "Gay Lussac" Method for Silver-Bullion Containing Tin.*

BY LUIS EMYLNN SALAS, NEW YORK, N. Y.

(San Francisco Meeting, October, 1911.)

If the ordinary wet method be attempted for silver-bullion containing tin, much trouble is experienced, varying with the amount of tin present. Even with a percentage as low as 0.05, the end-point is masked by a persistent turbidity, while with amounts ranging from 0.5 per cent. upward, the determination of the exact end-point is impossible, owing to the finely divided or colloidal metastannic acid resisting all efforts to cause it to settle, or to give a clear supernatant liquid.

The object of the following experiments was to seek a remedy for these difficulties, and to find the conditions whereby the Gay Lussac method might be applied directly to these bullions. Material containing tin is met with frequently in bullion from Mexico or Bolivia; and tin is carried (sometimes in large quantities) in jewelers' sweeps.

1. A bullion was prepared containing Ag, 74; Cu, 25; and Sn, 1 per cent.

A weighed amount was treated by the humid assay-method as if it were an ordinary bullion free from tin. Ten cc. of HNO_3 (1.21) was added, and the bottle was heated until all traces or red fumes had been expelled. Before heating, the solutions were moderately turbid; and after heating, the turbidity greatly increased.

One hundred cc. of normal NaCl solution was added and the bottle was shaken vigorously at intervals during 30 min. The turbidity persisted. The bottle was allowed to stand over

* Submitted in part fulfillment of the requirements for the degree of Master of Arts in the Faculty of Applied Science, Columbia University, and accepted for publication in the *Transactions* of the American Institute of Mining Engineers. Contribution from the Havemeyer Laboratories, Columbia University. No. 198.

night, and the next day it was found to be only moderately clear.

A slight agitation reproduced the troublesome turbidity, the precipitate failing to clear during the afternoon.

2. Various attempts were made to cause the precipitate to settle.

(*a*) The bottles were placed in a centrifugal machine and whirled for several minutes, but no appreciable settling took place.

(*b*) Mixtures of ether and alcohol were added, and the bottle was agitated. No desirable result was obtained.

(*c*) Several other assays were weighed out and treated as above with similar results. A small amount of egg albumen, in water solution, was added and heat applied to coagulate the albumen. Little or no clearing took place after shaking and allowing to stand. Frothing gave trouble, and the idea was abandoned.

(*d*) The production of heavy precipitates, such as $BaSO_4$, etc., to carry down the tin failed to give good results. Other attempts were made to cure the trouble, but none gave satisfaction.

It became evident that to seek a "prevention" would be more likely to lead to success.

3. Trials were made with many substances to keep the tin in solution, and the best results were obtained with the organic acids, tartaric and citric; but oxalic acid failed.

Two rows, *A* and *B*, of nine test-tubes each were arranged, and into each tube was placed a piece of tin weighing approximately 50 milligrams.

To 1, 2, 3 of set *A* was added . . .	0.1 g. of tartaric acid.
To 4, 5, 6 of set *A* was added . . .	0.25 g. of tartaric acid.
To 7, 8, 9 of set *A* was added . . .	0.5 g. of tartaric acid.
To 1, 2, 3 of set *B* was added . . .	0.1 g. of citric acid
To 4, 5, 6 of set *B* was added . . .	0.25 g. of citric acid.
To 7, 8, 9 of set *B* was added . . .	0.5 g. of citric acid.

Five cc. of HNO_3 (1.21) was added to each of the 18 tubes and in every case the contents were warmed.

To check the above results, three tests were made without the addition of an organic acid. The liquid remained clear where either tartaric or citric acid was used; whereas, those tests

containing neither tartaric nor citric acid became turbid on solution in the cold, and the turbidity increased on heating.

Even after considerable heating the tests Nos. 4 to 9 in each set remained clear.

But little difference could be noticed between the effects of tartaric and citric acids; if any, tartaric acid gave a slightly more satisfactory solution.

4. Further tests with tartaric acid were then made. A bullion containing Ag, 74; Sn, 2; and Cu, 24 per cent. was prepared, and three convenient quantities (*A*, *B*, and *C*) were taken for assaying. To each lot was added a small amount of tartaric acid (approximately 0.5 g.), and then 10 cc. of HNO_3 (sp. gr. 1.21). *C* alone gave a solution sufficiently clear for titration. (It was noted that *C* had not been heated as strongly as *A* or *B*.)

Two other tests, *D* and *E*, were made, 1 g. of tartaric acid being added to each, the bullion and crystal of acid being dissolved in HNO_3, as before. *D* became turbid on heating. It was observed that the turbidity greatly increased just before the red fumes disappeared. Test *E* also became turbid even in the cold. The precipitate appeared "silky" on rotating the bottle, and on warming to about 60° C. it diminished considerably, the solution becoming almost clear. Titration was attempted, but on diluting the silver solution with the 100 cc. of NaCl solution, the liquid would not clarify, even after prolonged agitation. The titration to the end-point was impossible with this assay.

5. It was observed that with regard to turbidity, the results obtained depended upon the heat-treatment. Therefore another series of experiments was undertaken upon ordinary bullion free from tin, with the object of testing the effects produced with and without tartaric acid, and with and without the application of heat. It was found that the presence of the tartaric acid and the omission to remove the red fumes (which removal is generally recommended and sometimes insisted upon) had no observable effect upon the accuracy of the assay. This last point being contrary to general practice, additional experiments were made to confirm it, giving the following results:

Assay.	Silver (c. p.) Taken. Milligrams.	Silver Found. Milligrams.
No. 1,	1005.55	1005.58
No. 2,	1005.81	1006.08
No. 3,	1005.49	1005.58
No. 4,	1005.71	1005.58

In all of these assays, c.p. silver was dissolved in HNO_3 (1 : 1) in the cold and titrated; all with tartaric acid; no heat applied.

6. A solution of NaCl was prepared and standardized, the standard equaling 1004.33 mg. of silver.

This solution was checked, and gave the following results:

Assay.	Amount of c. p. Taken. Milligrams.	Silver Found, Using the Standard Mentioned Above. Milligrams.
No. 1,	1005.44	1005.58
No. 2,	1005.33	1005.08
No. 3,	1005.27	1005.33
No. 4,	1006.63	1006.83
No. 5,	1005.92	1005.83
No. 6,	1005.22	1005.08

These tests were finished with NaCl.

To assays Nos. 5 and 6 there was added 2.5 cc. excess of decime NaCl, and the solutions were titrated back with decime $AgNO_3$, in the endeavor to ascertain the difference in end-point, finishing with NaCl and with $AgNO_3$. The solutions were agitated vigorously, but did not clear readily, and the end-point was obscure. This confirms the effect noticed by Aaron.

7. In the calculations the decime solution, as noted, was added 0.5 cc. at a time, and one-half of the last addition that gave a precipitate was counted.

Thus, 0.5 cc.
0.5 cc.
0.5 cc.
0.5 cc., no precipitate, equals 1.25 cc.

In order to determine if the addition of the decime solution in smaller amounts would make the end-point more exact, two tests were made, using 0.2 cc. decime NaCl.

A. 1005.21 mg. Ag. NaCl, 100 cc.
+ 0.2 + 0.2 + 0.2 + 0.2 + 0.2.
No precipitate.
= 1004.33 + 0.7.
= 1005.03 Ag found.

B. 1005.54 mg. Ag. NaCl, 100 cc.
+ 0.2 + 0.2 + 0.2 + 0.2 + 0.2 + 0.2.
No precipitate.
= 1004.33 + 0.9.
= 1005.23 Ag found.

The end-point was possibly less sharp, and the results were not improved.

8. In some of the previous assays certain effects were thought to be due to the amount of free HNO_3 present.

Two tests, *A* and *B*, were made to determine this point.

The c. p. silver was in each case dissolved in 10 cc. of HNO_3 without tartaric acid.

A was evaporated to incipient dryness. *B* was evaporated so that, on cooling, crystals of $AgNO_3$ separated. To each assay 100 cc. of NaCl solution was added, and the bottles briskly agitated. Neither of these solutions cleared well. *A* was especially cloudy. It was re-agitated and allowed to stand for 15 min., and titration continued, giving the following results:

A. Amount of silver taken, 1005.92 mg.; amount found, 1005.58 mg.
B. Amount of silver taken, 1005.50 mg.; amount found, 1005.83 mg.

Excess of $AgNO_3$ was then added to each test, but the solution did not clear well even after prolonged agitation, *A* being especially troublesome. To each, 5 cc. of HNO_3 (1.21) was added, and the agitation was repeated. Both solutions cleared perceptibly. The clearance was not complete in *A*, but *B* was very good. It appears, therefore, that the assay is best conducted in such a manner that considerable free HNO_3 remains after solution of the silver has taken place, and that excessive evaporation is disadvantageous even with tin-free bullions.

9. To determine the best strength of HNO_3, the following experiments were made:

About 250 mg. of bullion *D* (similar to *C*) was added to each of six test-tubes.

No.	H_2O Added. Cubic Centimeters.	HNO_3 (1.42). Added. Cubic Centimeters.	Results.
1	10	2	Few bubbles, dissolved after 5 hr.
2	8	4	Similar.
3	6	6	Quick action, clear solution.
4	4	8	Quick action, white sediment.
5	2	10	Quick action, white sediment.
6	0	12	No action at first. Ultimately heavy white sediment.

From the above tests, it was concluded that (1 : 1) HNO_3 (ordinary strong parting-acid) gives the best results.

The results obtained with bullion D were:

Amount Weighed Out. Milligrams.	Tartaric Acid. Grams.	NaCl. 100 cc.	Ag Equivalent. Milligrams.	Fineness.
1339.34	2	+ 0.75 dec.	1005.08	750.4
1339.54	2	+ 0.75	1005.08	750.3
1339.61	2	+ 0.75	1005.08	750.2
1340.65	2	+ 2.0	1006.33	750.6

10. It was found desirable, in assaying silver bullion containing tin, that the tartaric acid should be immediately available for the dissolution of the tin. We therefore proposed to dissolve the 2 g. of tartaric acid (a convenient quantity for bullions containing about 5 per cent. of Sn) in about 3 cc. of water in the assay-bottle before adding the HNO_3.

11. Bullion A was prepared containing 0.1 per cent. of tin; fineness, 750. The copper used was found to contain a little silver (this was discovered later when looking for the reason of the high results).

No.	Amount of Bullion. Milligrams.	Tartaric Acid. Grams.	NaCl. 100 cc.	Ag Equivalent. Milligrams.	Fineness.
1	1338.76	1	+ 0.75 dec.	1005.08	750.7
2	1338.91	0.5	+ 0.75 dec.	1005.08	750.6
3	1338.84	1	+ 1.0 dec.	1005.33	750.8
4	1338.53	0.5	+ 1.0 dec.	1005.33	750.9

A cloudiness appeared in the above tests when bringing the silver into solution, but this cloud disappeared on warming. No. 3 was actually brought to the boiling-point without special trouble occurring, the percentage of tin being small. But this heating is not permissible with bullions containing large amounts of tin.

Additional experiments, Nos. 5 and 6, were carried out as follows: No. 5 contained no tartaric acid, and the solution was heated till the red fumes were expelled. The solution did not clear well, and the end-point could not be ascertained with certainty.

No. 6 contained 1 g. of tartaric acid, and was dissolved at room-temperature. The solution remained clear till the end, and gave a sharp end-point. The fineness found was 750.8.

12. Bullion B contained 1 per cent. of Sn, and was approximately 750 fine.

The results obtained were similar to those of Bullion *A* in experiment 11, except that the turbidity, where occurring, due to lack of tartaric acid, was more marked.

Bullion *C* contained 5 per cent. of Sn, and was approximately 750 fine. In accordance with the observation made in experiment 6, with regard to the better clearing of the liquid when finishing with NaCl rather than with $AgNO_3$, in all these assays an amount of bullion was weighed out, so that excess of silver remained in the assay-bottle after adding the 100 cc. of NaCl. Citric and tartaric acid were tried. The assay containing citric acid would not settle at all, the liquid retaining its milky appearance for a whole day; moreover, the AgCl did not granulate well. Other tests confirmed the fact that citric acid is useless for the purpose. Tartaric acid, however, gave exceedingly good results so far as the clearing of the solution was concerned.

The experiments with this bullion containing 5 per cent. of Sn seemed to indicate:

(1) That the best clearance was obtained when few additions of decime NaCl were necessary.

(2) That the bullion must be dissolved in the cold. (In some cases the bottles were cooled under the tap with advantage, after dissolving the tartaric acid, and before adding the HNO_3).

(3) That 2 g. of tartaric acid gave satisfactory results; 1 g. appeared insufficient, and 3 g. indicated some interference with the end-point.

Above all, the best results were obtained when sufficient bullion was taken to provide an excess of silver, the titration taking place entirely on the salt side.

13. Bullion *E*, made up of similar composition to that of *D* (5 per cent. of Sn), was granulated, and, after granulation, was found to be thickly coated with oxides. Bullions that are oxidized to a considerable extent give trouble in dissolving, as heat, necessary for complete dissolution, causes the separation of metastannic acid. Moreover, it was observed that although a clear solution (strongly acid) might sometimes be obtained, an intense turbidity was produced on diluting with the 100-cc. NaCl solution, and that settling was impossible even after prolonged agitation, due to the alteration of the state of hydration of the tin oxide.

It is to be noted here that all bullions that had been heated strongly gave precipitates (on dilution) which did not settle.

14. Bullion *F*, containing approximately Ag, 75; Cu, 20; and Sn, 5 per cent., was poured into the form of a conical button, which was flattened and rolled, thus increasing the chances of obtaining a uniform assay-piece.

The bullion was first placed in the bottle, then 2 g. of crystals of tartaric acid, then 3 or 4 cc. of distilled water was added, and the liquid heated till the crystals had dissolved. The solution was well cooled, and then was added 10 cc. of HNO_3 of a strength slightly greater than (1 : 1) to counterbalance the water added to dissolve the tartaric acid.

The bullion was allowed to dissolve in the cold, and complete solution took place in about 20 min. The following results were obtained:

No.	Bullion Taken. Milligrams.	NaCl. 100 cc.	Ag Equivalent. Milligrams.	Fineness.
1	1338.60	+ 1.75 dec.	1006.08	751.5
2	1338.74	+ 1.75 dec.	1006.08	751.5
3	1338.13	+ 1.50 dec.	1005.83	751.3
4	1338.21	+ 1.25 dec.	1005.58	751.4
5	1338.49	+ 1.0 dec.	1005.33	751.1
6	1337.54	+ 0.25 dec.	1004.58	751.0
7	1337.60	+ 0.25 dec.	1004.58	751.0
8	1337.48	+ 0.25 dec.	1004.58	751.1
9	1337.64	+ 0.25 dec.	1004.58	751.0
10	1337.79	+ 0.25 dec.	1004.58	750.9
11	1338.58	+ 1.25 dec.	1005.58	751.2
12	1337.83	+ 0.25 dec.	1004.58	750.9
			Average,	751.16

The above results are very concordant, but there was a possibility of a uniform error existing. To check this point known weights of Ag (c.p.), Cu, and Sn were taken and placed loosely in assay-bottles, *A* and *B*.

A contained Ag (c. p.), 1005.66; Cu, 250.80; and Sn, 60.46 mg.

B contained Ag, 1005.52; Cu, 250.44, and Sn, 77.66 mg.

These assays were treated by the method given in the *résumé* at the end of this paper.

Amount of NaCl required in $A = 100$ cc. NaCl + 1.50 dec.

$B = 100$ cc. NaCl + 1.25 dec.

Ag equivalent of $A = 1005.83$.

Ag equivalent of $B = 1005.58$.

The above method of treatment is the proper one for bullions containing tin.

15. An attempt was made to apply the method given in Experiment 14 directly to a 20-per cent. Sn alloy.

The tests were prepared thus:

	Ag (c. p.). Milligrams.	Cu. Milligrams.	Sn. Milligrams.
Bottle *A* contained	1005.20	250.25	200.15
Bottle *B* contained	1005.52	250.61	200.30

The assays were treated by the method given in the *résumé*. Good clear solutions were obtained while the HNO_3 remained relatively concentrated; but on dilution with the 100-cc. NaCl solution a heavy cloud was produced, which did not clear by agitation and standing. If the percentage of tin in the bullion is so great that it interferes with this method, decrease the amount of bullion taken and make up the deficit of silver by adding c. p. Ag.

16. As a check upon the method it was desirable to make a fire-assay.

Bullion *F* having been exhausted, another bullion, *G*, was prepared of the following composition:

Ag, 22.5; Cu, 5; and Sn, 1.5 g., having a fineness of 750, and containing 5 per cent. of tin.

The strong NaCl solution was re-standardized. The standard had not altered (= 1004.33 mg. of Ag). The bullion was treated by the method indicated in the *résumé*. The results were:

	Bullion. Milligrams.	NaCl 100 cc.	Ag Equivalent. Milligrams.	Fineness.
A. {	1339.66	+ 0.25 cc. dec.	1004.58	749.9
	1339.78	+ 0.25 cc. dec.	1004.58	749.9
	1340.14	+ 0.75 cc. dec.	1005.08	750.0
	1341.04	+ 1.25 cc. dec.	1005.58	749.8
	1340.21	+ 1.25 cc. dec.	1005.58	750.3
	1341.47	+ 1.75 cc. dec.	1006.08	750.0
			Average,	749.98

The bullion-assays marked *A* were titrated by an independent assayer, the amounts of bullion taken being "unknown."

Other results obtained by independent assayer upon unknown

quantities of alloy were: 749.9; 750.3; 749.8; 750.1; 750.4; averaging 705.1.

17. To check the results of experiment 16, the following fire-assays were made:

Three bullion assay-pieces were weighed out:

(1) 500.05 mg.	(2) 500.44 mg.	(3) 500.19 mg.

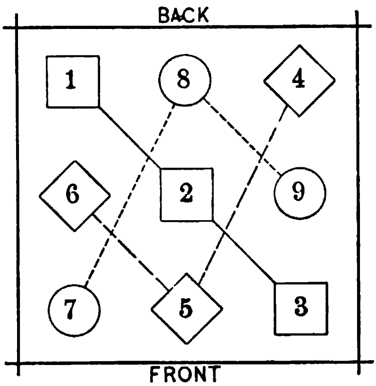
Three checks were made up containing tin:

(4) 375.12 mg. Ag.	(5) 375.26 mg. Ag.	(6) 375.12 mg. Ag.
100.10 mg. Cu.	100.12 mg. Cu.	100.08 mg. Cu.
24.95 mg. Sn.	25.16 mg. Sn.	25.06 mg. Sn.

Three checks containing no tin (these were run in order to determine if the tin had any effect upon the results for silver):

(7) 375.30 mg. Ag.	(8) 375.00 mg. Ag.	(9) 375.00 mg. Ag.
100.42 mg. Cu.	100.20 mg. Cu.	100.34 mg. Cu.

The nine cupels were surrounded on all sides by old cupels, and a bar of fire-brick was placed at the door of the furnace. None of the beads sprouted. The relative positions of the bullions and checks were as shown in diagram:



Weight of prills obtained:

(1) 368.39 mg.	(8) 368.60 mg.	(4) 368.90 mg.
(6) 368.88 mg.	(2) 369.70 mg.	(9) 369.02 mg.
(7) 370.32 mg.	(5) 368.52 mg.	(3) 370.07 mg.

Loss on (8) = 6.40 mg.; loss on (4) = 6.22 mg.

Loss on (6) = 6.42 mg.; loss on (9) = 5.98 mg.

Loss on (7) = 4.98 mg.; loss on (5) = 6.74 mg.

Mean loss on back row = 6.31 mg. (add to assay 1).

Mean loss on middle row = 6.11 mg. (add to assay 2).

Mean loss on front row = 5.86 mg. (add to assay 3).

Therefore,

368.39 + 6.31 = 374.70 mg. corrected Ag found in (1).
369.70 + 6.11 = 375.81 mg. corrected Ag found in (2).
370.07 + 5.86 = 375.93 mg. corrected Ag found in (3).

$$\text{Fineness as determined by } \left.\begin{array}{l}(1) = 749.3\\(2) = 750.9\\(3) = 751.1\end{array}\right\}\text{Average, } 750.4$$

Since the checks 7, 8, 9 contained no tin, they are not strictly comparable with the bullion-assays 1, 2, 3.

Calculating from 4, 5, 6, containing tin, the results are:

Prill No. 1: 368.39 + loss on 4 (6.22 mg.) = 374.61 (= 749.1 fine).

Prill No. 2: 369.70 + loss on 6 (6.42 mg.) = 376.12 (= 751.1 fine).

Prill No. 3: 370.07 + loss on 5 (6.74 mg.) = 376.81 (= 753.3 fine).

Other checked fire-assays were run on the same bullion. Amounts weighed out: *A*, 500.05; *B*, 500.13; *C*, 500.12.

Prill from *A* (367.46) + loss on check (7.01 mg.) = 374.47 (= 748.9 fine).

Prill from *B* (366.26) + loss on check (8.17 mg.) = 374.43 (= 748.7 fine).

Prill from *C* (367.60) + loss on check (7.54 mg.) = 375.14 (= 750.1 fine).

The average fineness calculated from these six fire-assays was 750.2.

NOTE.—The tests without tin were run as checks upon those containing tin. If the abnormal results obtained in 5 and 7 be discarded, the average losses on the assays with and without tin agree closely, indicating that the presence of tin has little or no effect upon the results of the fire-assay.

Résumé of Method.

1. Place a weighed amount of bullion in assay-bottle and add tartaric acid crystals. Then add 3 or 4 cc. of distilled water. Apply heat until the tartaric acid is dissolved.
2. About 2 g. of tartaric acid is a convenient quantity to use with 1 g. of a bullion containing up to 5 per cent. of tin. After dissolution of the tartaric acid, cool thoroughly.

3. 10 cc. of HNO_3 (1 : 1, or a little stronger) is now added, and the bottle rotated slightly to mix the two acids thoroughly. Keep the solution cool.
4. The amount of bullion to be taken must be such as to leave an excess of silver in the solution after the 100 cc. of NaCl has been added.
5. The bullion must be dissolved in the cold. It is not necessary to boil off the nitrous fumes.
6. The assay must not be heated after the HNO_3 has been added.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Rational Valuation and Quality-Efficiency of Furnace-Stock.

BY JOHN JERMAIN PORTER,* CINCINNATI, OHIO.

(San Francisco Meeting, October, 1911.)

THE value of any particular ore, coke, or limestone, for iron-making, depends upon its effect, first, upon the quality or value of the resultant product; and second, upon the cost of smelting. The factors under the first head are the percentages of phosphorus, manganese, and other elements, which remain in the pig-iron; while those under the second head are the percentages of iron, carbon, or lime, the slag-forming constituents, which must be fluxed, and any other ingredients which give rise to variations in cost of fuel and flux.

The first of these criteria of value is perhaps not capable of being reduced to a general formula embracing all cases, since it must vary to a great extent with market-fluctuations. For example, Bessemer pig is worth sometimes more and sometimes less than foundry-pig; and the premium paid for high manganese varies within wide limits. The second, or smelting-value, however, can be expressed numerically with a fair degree of accuracy; and it is with this phase of valuation that the present paper is concerned.

The utility of a means of comparing numerically the relative smelting-values of different ores, cokes, and limestones, is self-evident, although it may not have importance in Northern practice, where materials are largely standardized. On the other hand, there are, especially in the South, many furnace-managers who must use a great variety of materials of widely varying grade; and it is with special reference to this district, and in connection with the efficiency-methods which I have elsewhere proposed,[1] that the methods herein described were devised.

---

* University of Cincinnati.

[1] Cost Reduction in the Iron Industry, *Manufacturers' Record*, vol. lix., No. 5 (Feb. 9, 1911).

Previous work along this line has been confined chiefly to the valuation of ores. Moreover, none of the methods which I have examined [2] have met the requirements of my own particular needs. The methods which follow lack somewhat in scientific completeness, and depend to a regrettable extent upon factors which must be chosen empirically by experience. Nevertheless, I claim for them the two requisites of practical usefulness, namely, simplicity and substantial accuracy.

Method for Iron-Ores.

The basis of this method is the percentage of iron, silica plus alumina, lime plus magnesia, and the ease of reduction as measured by the burden-ratio which can be carried in average practice.

Let Fe = percentage of iron.

RO = percentage of lime plus magnesia.

V = value of iron per unit.

v = value of coke per short ton.

q = value of RO per unit.

Ac = percentage of silica plus alumina.

n = percentage of Ac in coke ÷ 100.

m = long tons of coke per ton of ore.

$$r = \text{burden-ratio} = \frac{\text{ore} + \text{stone}}{\text{coke}} \qquad (1)$$

The term "unit" refers to 1 per cent. of a long ton, or 22.4 lb.

Value of ore per ton = value of Fe + value of RO — value of RO to flux Ac — value of coke to smelt. (2)

[2] The Valuation of Iron-Ores, by M. Drees. *Stahl und Eisen*, vol. xxvii., No. 10, p. 330 (Mar. 6, 1907).

The Valuation of Ores, by A. Rzehulka. *Zeitschrift für angewandte Chemie*, vol. xxiii., No. 11, p. 481 (Mar. 18, 1910).

Observations on the Purchase of Ore, by C. Chordot. *Revue de Métallurgie*, vol. viii, No. 3, p. 289 (Mar., 1911).

Comparison of Some Southern Cokes and Iron Ores, by A. S. McCreath and E. V. D'Invillers. *Trans.*, xv, 734 (1886–87).

Notes on the Selection of Iron-Ores, Limestones and Fuels for the Blast-Furnace, by F. W. Gordon. *Trans.*, xxi., 61 (1892–93).

Rules for Adjusting Premiums and Penalties on Lake Superior Iron Ores, by Geo. Smart. *Iron Trade Review*, vol. xlviii., No. 10, p. 495 (Mar. 9, 1911.).

The Blast Furnace and the Manufacture of Pig Iron, by Robert Forsythe. 1st ed., pp. 47, 85 and 89 (1908).

The Calculation of the Value of the Raw Material in Pig Iron Making, by A. P. Gaines. *The Iron Age*, vol. lxxiii., No. 15, p. 12 (Apr. 14, 1904).

From (1), long tons of coke to smelt 1 ton of ore =

$$\frac{1 + \text{stone per ton of ore}}{\text{r}} \tag{3}$$

Assume that in the slag Ac = RO. This is so nearly true as to introduce only an inappreciable error, even with widely varying practice. Also assume that two tons of stone give one ton of RO.

Then tons of stone to flux coke-ash = 2 nm;
and tons of stone per ton of ore =

$$2\left(\frac{\text{Ac}}{100} - \frac{\text{RO}}{100}\right) + 2\ \text{nm}. \tag{4}$$

Hence, substituting (4) in (3),
Long tons of coke per ton of ore =

$$\frac{1 + 2\left(\frac{\text{Ac}}{100} - \frac{\text{RO}}{100}\right) + 2\ \text{nm}}{\text{r}} \tag{5}$$

and short tons of coke per ton of ore =

$$\frac{1 + 2\left(\frac{\text{Ac}}{100} - \frac{\text{RO}}{100}\right) + 2\ \text{nm}}{1.12\ \text{r}} \tag{6}$$

Hence, substituting in (2),
Value of ore = V Fe + q RO — q Ac — v

$$\left(\frac{1 + 2\left(\frac{\text{Ac}}{100} - \frac{\text{RO}}{100}\right) + 2\ \text{nm}}{1.12\ \text{r}}\right) \tag{7}$$

This method gives the true smelting-value of an ore, except that it does not take into account differences in the desirability of the slag made, due to the ratio of lime to magnesia, or of silica to alumina, or to the presence of titanium. If desired, account can be taken of the exact relation between the per cent. of bases and acids in the slag, and of the exact number of tons of limestone to give one ton of RO. However, these refinements make the formula considerably more cumbersome to use, and are unnecessary for substantial accuracy.

It will be noted that n is the percentage of acids (silica and alumina) in the coke, not the per cent. of ash. A considerable proportion of coke-ash is usually iron, which does not need fluxing. Occasionally there is a large amount of lime and magnesia in the ash; and in such cases it would be proper to consider n as the difference between the acids and the bases, or in other words, as the unfluxed acids. However, this is a matter of minor importance. Such changes as are likely to occur in q, n, and m have but little effect on the results, the two important factors being the value given to the unit of iron and the price of coke. Since the value of the iron-unit varies somewhat in different iron-making districts and at different times, it is my custom, when starting to compare a series of ores in this way, to try several values of V on some typical ore, finally adopting that value which gives results approximating actual prices. The following values for the various constants generally give good results:

$V = 0.07$ to 0.09. $\quad v = \$2$ to $\$3$.
$q = 0.01$. $\quad n = 0.10$.
$r = 1.5$ to 2.5. $\quad m = 0.6$.

The following is a comparison by this method of typical ores used in leading manufacturing centers of the world. In order to compare them, I have assumed that they are smelted under the same conditions and have used the following constants: $V = \$0.08$, $v = \$3$, $q = \$0.01$, $n = 0.10$, $m = 0.6$. In one sense this assumption is misleading, since commercial value is very largely a function of cost of fuel and market for product. Hence an ore may be worth considerably more than indicated here, if located adjacent to cheap coke and a good market. This objection does not, of course, apply to the use of the method in comparing ores for any given furnace or district.

Ore.	r.	Fe.	Ac.	RO.	Value.
Lake Superior, Mesabi,	2.5	53.0	11.0	——	$2.70
Alabama, hard red ore,	1.7	35.0	15.0	18.0	1.17
Brown hematite, Virginia,	2.3	45.0	20.0	——	1.64
Magnetic concentrates,	1.5	60.0	12.0	1.0	2.32
"Ironstone," Cleveland, Eng.,	2.1	32.0	15.0	11.0	1.02
"Minette" ore, Germany,	2.3	35.0	15.0	15.0	1.51

Method for Coke.

The value of coke for use in the blast-furnace depends on:

1. The percentage of carbon, since it is only the carbon which by its combustion produces heat.

2. The ease with which the coke is dissolved by carbon dioxide, since this determines in part the amount of carbon reaching the hearth of the furnace.

3. The percentage of ash, since the ash not only displaces carbon, but requires lime to flux it, and additional carbon to melt the slag formed from it.

The percentages of sulphur and of phosphorus may be disregarded in this connection, as not affecting the heating-value of the coke, although, of course, they affect the quality of the iron made from it. It may be objected here that the presence of much sulphur necessitates the use of a more basic slag and a higher temperature in the hearth, and in this way increases the amount of necessary fuel. Yet, while the truth of this statement must be admitted, its consideration in a workable formula does not seem practicable, and it is not often a matter of great importance.

A general expression for the value of coke is:

Value per short ton = value of carbon reaching hearth — value of carbon to smelt slag from ash — value of RO to flux ash.

Let FC = percentage of fixed carbon in coke.
Ac = percentage of silica + alumina in coke.
f = factor of solubility of coke in carbon dioxide.
r′ = reducibility-factor of ore.
RCO3 = pounds of lime and magnesia carbonates per ton of iron.
F = fuel-consumption in short tons of coke per ton of iron.
Ha = heat available in hearth of furnace per pound of carbon burned.
U = value of each unit of available carbon.
q = value of each unit of RO (long-ton units).

The term unit refers to 1 per cent. of one short ton, or 20 lb., except where otherwise noted.

The units of carbon reaching the hearth = FC — carbon-loss between throat and hearth.

The carbon-loss between throat and hearth I have shown elsewhere[3] to equal, per ton of iron, 0.12 × pounds of carbonates per ton of iron × size, factor of stone × factor of solubility of coke + 700 × reducibility, factor of ore × factor of solubility of coke. The size-factor of stone is unimportant and may be neglected.

Hence, units of carbon lost per short ton of coke =

$$(0.12 \times RCO3 \times f) + (700 \times r' \times f) \times \frac{1}{20\,F}$$

or, simplifying $= \frac{f}{20\,F}(0.12\ RCO3 + 700\ r')$.

Hence, value of carbon reaching hearth =

$$U\left(FC - \frac{f}{20\,F}(0.12\ RCO3 + 700\ r')\right) \text{ per short ton.}$$

The slag resulting from the ash is 2 Ac units per ton of coke. The carbon to smelt one unit of slag is (from the paper previously cited) $\frac{600}{Ha}$.

Hence the value of the carbon to melt the slag from the coke-ash

$$= U\left(\frac{2\ Ac}{1} \times \frac{600}{Ha}\right) = U\left(\frac{1200\ Ac}{Ha}\right)$$

Finally, the short tons of RO required to flux the coke-ash = Ac (if we assume, as in the case of ores, that in the slag the per cent. of Ac equals the per cent. of RO), or the long ton units of RO = 1.12 Ac, and the value of the RO = q × 1.12 Ac.

Hence the value of the coke per short ton =

$$U\left(FC - \frac{f}{20\,F}(0.12\,RCO3 + 700\,r') - \frac{1200\ Ac}{Ha}\right) - 1.12\ q\ Ac.$$

Values of constants which I have found to give good results are as follows:

[3] The Fuel-Efficiency of the Iron Blast-Furnace, *Bulletin* No. 53, May, 1911, p. 373.

$U = 0.04$ to 0.06.
$q = 0.01$.
$f = 0.5$ for the best Connellsville coke.
0.6 to 0.7 for good Pennsylvania and West Virginia coke.
0.8 to 0.9 for fair Virginia and Alabama coke.
1.0 for the softest Pocahontas and Alabama coke.
$r' = 0.1$ for Mesabi ore.
0.2 for brown hematites.
0.3 for soft red hematites and roasted carbonates.
0.4 for hard red hematites.
0.6 for Alabama hard red ore.
1.0 for magnetites and mill-cinders.

The factor f simply represents that proportion which the carbon actually dissolved bears to that which could be possibly dissolved by the CO_2 present. For example, if there are 700 lb. of carbon present as CO_2 per ton of iron, then according to the reaction $C + CO_2 = 2\,CO$, 700 lb. is the maximum amount of carbon which can be dissolved per ton of iron. If good Connellsville coke with a solubility-factor of 0.5 is used, the amount of carbon actually dissolved and thereby wasted will be $700 \times 0.5 = 350$ lb., while with fair Alabama coke the amount lost would be $700 \times 0.8 = 560$ lb. The values given for this factor are based on no experimental evidence (except in a qualitative way), but were chosen because they give good results in furnace-calculations. I believe they are a fair approximation to the truth.

The factor r′ represents that proportion of the oxygen of the ore which is only removed at such high temperatures that the resulting CO_2 has power to dissolve carbon. It requires approximately 700 lb. of carbon to reduce the iron in one ton of pig-iron by the reaction $Fe_2O_3 + 3\,CO = Fe_2 + 3\,CO_2$. If this CO_2 were produced at such a high temperature that it all reacted thus: $CO_2 + C = 2\,CO$, there would be 700 lb. of carbon dissolved in this way, and r′ is the proportion of this maximum loss which actually occurs. The values used are in qualitative accordance with laboratory-experiments, and give good results when used in furnace-calculations; otherwise they have no scientific basis.

It will be noted that another kind of reducibility-factor is used here than in the case of iron-ores. It must be admitted that this is a very unscientific procedure; but the use of the burden-ratio to express relative reducibility finds its justification in the much greater simplicity of the calculations in the case of iron-ores. I have not as yet worked out the scientific relationship between r and r′, but an approximate empirical relation is given by the expression $r' = \frac{5}{r^4}$.

Ha, the heat available in the hearth of the furnace per pound of carbon, has been discussed by Johnson[4] and by me.[5] Its calculation is very lengthy, but by means of the diagrams in the two papers just referred to it can be read off directly. Ha is usually about 1,500 for Alabama practice, 1,600 for Virginia practice, and 1,400 for Northern practice.

Method for Limestones.

Let q′ = value of lime and magnesium carbonates per unit of 22.4 lb.

v = value of coke in dollars per short ton.

Ac = per cent. of silica plus alumina in the stone.

Ha = heat available in the hearth of the furnace per pound of carbon.

FC = per cent. of fixed carbon in the coke.

Relative value = value of available carbonates — value of coke to flux slag from siliceous impurities.

Available carbonates = 100 per cent. — per cent. Ac — per cent. carbonates to flux Ac.

Per cent. carbonates to flux Ac (assuming RO = Ac in slag) = 1.785 Ac if pure calcium carbonate, or = 1.911 if pure dolomite. Say = 1.8 Ac for average practice.

Hence available carbonates = 100 — Ac — 1.8 Ac. = 100 — 2.8 Ac.

Short tons of coke to melt slag per ton of stone =

$$\frac{\text{pounds of slag per ton stone} \times 600}{\text{Ha} \times \frac{\text{per cent. FC}}{100} \times 2000}$$

Pounds of slag per ton of stone $= \frac{2\ \text{Ac}}{100} \times 2240.$

[4] *Trans.* xxxvi., 476 (1906).

[5] *Bulletin* No. 53, May, 1911, p. 375.

Therefore the short tons of coke to smelt the slag per ton of stone =

$$\frac{\frac{2\ \text{Ac}}{100} \times 2240 \times 600}{\text{Ha} \times \frac{\text{per cent. FC}}{100} \times 2000},$$

$$\text{or simplifying,} = \frac{1344\ \text{Ac}}{\text{Ha} \times \text{per cent. FC.}}$$

Therefore value of stone =

$$q' \times (100 - 2.8\ \text{Ac}) - v \times \frac{1344\ \text{Ac}}{\text{Ha} \times \text{per cent. FC.}}$$

Examples of the Use of these Formulæ.

During a portion of the year 1909 a certain Southern furnace used materials of which the following are the extremes in composition, as shown by the best and poorest analyses on the furnace-books.

		Iron. Per Cent.	Silica + Alumina. Per Cent.	Lime + Magnesia. Per Cent.
Ore 1, hard red ore,	best,	46.54	6.90	11.54
	poorest,	33.00	23.40	12.50
Ore 2, hard red ore,	best,	36.30	19.40	12.25
	poorest,	33.03	26.92	11.29
Ore 3, soft red ore,	best,	50.70	19.10	2.40
	poorest,	38.60	34.80	2.00
Ore 4, soft red ore,	best,	49.20	27.60	....
	poorest,	35.77	45.00	....
Ore 5, brown ore,	best,	44.10	21.00	....
	poorest,	39.29	28.30	....
Ore 6, brown ore,	best,	41.10	26.05	....
	poorest,	30.10	46.30	....
Ore 7, brown ore,	best,	49.60	18.20	....
	poorest,	36.04	34.02	....
Limestone 1, . . .	best,		3.01	
	poorest,		9.57	

		Fixed Carbon. Per Cent.	Ash. Per Cent.	Silica + Alumina. (Approximate). Per Cent.
Coke 1, ...	best,	85.80	13.75	10.75
	poorest,	75.65	22.25	19.25
Coke 2, ...	best,	82.22	16.58	13.58
	poorest,	77.80	20.58	17.58

The various constants entering into the calculation of the relative values of these materials may be taken as follows:

$V = 0.09$	$v = \$3.00$
$q = 0.01$	$n = 0.15$ (average.)
$m = 0.6$	$U = 0.05$
$r = 1.7$ for hard red ore.	$F = 1.7$
$r = 2.0$ for soft red ore.	$Ha = 1500$
$r = 2.3$ for brown ores.	$f = 0.9$
$FC = 80$ per cent. (average.)	$r' = 0.5$ (average of all ore used.)
$q' = 0.008$	$RCO_3 = 2600$

Hence the equations for this particular furnace and period may be simplified to the following:

Value of ore =

$$0.09\ Fe + 0.01\ (RO - Ac) - \frac{3.9 + 6\left(\frac{Ac - RO}{100}\right)}{1.12\ r}$$

Value of coke $= 0.05\ (FC - 17.5 - 0.8\ Ac) - 0.0112\ Ac.$
Value of limestone $= 0.012\ (100 - 2.8\ Ac) - 0.0336\ Ac.$

The relative values of these materials, figured on this basis, together with the approximate actual costs delivered at the furnace, are as follows:

	Relative Value.		Approximate	Relative Desirability (*i. e.* Value ÷ by Cost).	
	Best Material.	Poorest Material.	Actual Cost.	Best Material. Per Cent.	Poorest Material. Per Cent.
Ore 1, . . .	\$2.33	\$0.50	\$1.20	194.2	41.7
Ore 2, . . .	0.93	0.27	1.20	77.5	22.5
Ore 3, . . .	2.17	0.49	2.00	108.5	24.5
Ore 4, . . .	1.63	0.23	1.50	108.6	zero
Ore 5, . . .	1.78	1.10	2.00	89.0	55.0
Ore 6, . . .	1.34	0.32	1.75	76.6	zero
Ore 7, , . .	2.36	0.61	2.00	118.0	30.5
Limestone 1,	0.63	0.27	0.60	105.0	45.0
Coke 1, . .	2.86	1.92	3.00	95.3	64.0
Coke 2, . .	2.54	2.11	3.00	83.7	70.4

As a matter of fact in this particular case, the ore-situation was such that almost anything was welcome that would help keep the furnace going; and the operating officials were fully aware of the inefficiency of some of the material used. Never-

theless, I think that the value of such a comparison as the above will be generally admitted.

One of the great difficulties in the way of economical production is the frequent lack of co-ordination between different departments. It is quite commonly the case that foremen have as their ideals the good of their own departments rather than the good of the whole organization; and it is indeed an efficient executive who can hold all the details of a large operation so firmly as to eliminate all waste due to friction between the parts.

In the South especially, a considerable amount of unnecessary waste is often due to wrong ideals on the part of the miners and mine-foremen. Finding that success is gauged almost entirely by the elements of cost and output, it is natural that they should devote all their energies to making a good showing along these lines, while quality is neglected, except perhaps spasmodically when the blast furnace superintendent makes some particularly strenuous objection. The latter is usually the only person who is particularly interested in this question of quality; and he is seldom in a position to determine what standards are proper and how much of the poor material used was really unnecessary.

It appears to me that, in such cases, efficiency-reports, if properly constructed, should be of special value in giving a true basis upon which to evaluate the work of each department, and in helping each member of the organization to more useful ideals. My idea for carrying out this plan, as worked out in connection with other phases of furnace-efficiency, involves the use of three reports. The first, Table I., is a periodic, preferably daily, blast-furnace stock-efficiency report, made up from the analyses of the materials as shipped, and preferably sampled at the furnace. The second, not shown, is the daily operation-report of each mine-washer and coking-plant, and would have to vary in its make-up according to the nature of the operation. The third, Table II., is a weekly or monthly comparative mine-efficiency report. It will be noted that on this the efficiency as to cost, output, and quality is shown separately, while the total efficiency is the product of these three. Of course there are many possible variations in carrying out this idea, and every case will probably need a

little different treatment. Bonus-payments for high efficiency to those in charge are a very desirable, though not absolutely necessary, corollary to the plan.

It is not within the province of the present paper to consider the question of standards for cost and output; but the matter of quality-standards can, in the case of coal, limestone, and bedded ores, be handled as follows: At regular periods, say once a week, a careful and reliable man goes through the mine and takes an adequate sample representing all, or a majority, of the working-faces. This sample excludes all partings which should theoretically be thrown out in mining, and its analysis, representing the best quality possible if the mining is perfectly done, becomes the standard for that week and affords the basis for calculating the standard for relative value. In the cases of brown-ore deposits, ore- and coal-washers, and coke-ovens, special methods of sampling must be devised for each individual case.

It may be objected that this plan calls for an undue amount of analytical work. This, however, need not be the case if the work is carefully planned; and, in any event, the benefits which are usually to be derived will warrant a considerable addition to the laboratory expense. As an example, I may cite the case of a company which has been using coke averaging 18 per cent. in ash, although it was demonstrated, when special attention was given to this feature, that their coal is capable of making a coke of only from 13 to 14 per cent. of ash. This increased ash is responsible, in that case, for an increase of approximately 300 lb. of fuel per ton of iron and an increased cost of about 40 cents per ton of iron.

On the other hand, I am acquainted with a coal-operation where the adoption of methods somewhat similar to, though less complete than, those I have advocated, has led to a decrease in the average ash in the coal shipped from 16 to 12.60 per cent. within a period of three months. Finally, it is well known that a leading Southern producer has been able to attain most remarkable results both as to low ash and uniformity of composition in its coke by the use of methods which contain the spirit, if not the outward form, of those I have here described.

TABLE I.—*Daily Stock-Efficiency Report.*

DAILY STOCK EFFICIENCY REPORT.

....Furnace. Date,..................................

Ore.		Iron.	Insoluble.	Bases.	Relative Value.	Efficiency.
		Per Cent.	Per Cent.	Per Cent.		Per Cent.
No. 1.	Standard.	46.54	6.90	11.54	2.53	
	Actual.	33.00	23.40	12.50	0.50	21.4
No. 2.	Standard.	36.30	19.40	12.25	0.93	
	Actual.	33.03	26.92	11.29	0 27	29.0
No. 5.	Standard.	44.10	21 00	....	1.78	
	Actual.	39.29	28.30	....	1.10	61.8
Flux.						
No. 1.	Standard.		3.01		0.63	
	Actual.		9.57		0.27	42.8

Coke.		Ash.	Fixed Carbon.	Relative Value.	Efficiency.
		Per Cent.	Per Cent.		Per Cent.
No. 1.	Standard..............	13.75	85.80	2.86	
	Actual..................	22.25	75.65	1.92	67.1
No. 2.	Standard..............	16.58	82.22	2.54	
	Actual..................	20.58	77.80	2.11	83.1

NOTE.—It is contemplated that the relation between the percentage of silica plus alumina and the per cent. of insoluble, and the per cent. of silica plus alumina in the ash be determined and occasionally checked, and that a suitable instruction-sheet be furnished whereby the chemist can calculate the relative value with the minimum of labor.

TABLE II.—*Weekly Comparative Mine-Operation Report.*

WEEKLY COMPARATIVE MINE-OPERATION REPORT.

Week ending............................

Operation.		Cost.		Output.		Quality.		Total Efficiency.
			Efficiency.	Tons.	Efficiency.	Relative Value.	Efficiency.	
		Dollars.	Per Cent.		Per Cent.		Per Cent.	
No. 1.	Standard.	0.80		300		1.78		
	Actual.	0 90	88.9	310	103.3	1.10	61.8	56.7
No. 2.	Standard.							
	Actual.							
No. 3.	Standard.							
	Actual.							

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Mineral Production and Resources of China.

BY THOMAS T. READ,* SAN FRANCISCO, CAL.

(San Francisco Meeting, October, 1911.)

I. INTRODUCTION.

WHEN so much has been written upon a subject on which so little definite information is available as upon this, some reason must needs be assigned for adding to the volume of literature. A sufficient reason is found in the probable great future importance of China as a producer of mineral wealth. The present undeveloped state of mining in the Empire is due to many causes, among which the most important are the relatively simple needs of the population, the lack of transportation-facilities, the inelastic regulations governing the industry, and the superstitious reluctance of the people to make excavations which might disturb the spirits of the earth and air, or of ancestors.

Iron is the metal most in demand, yet the needs of the population, until recently, only made necessary a production of approximately 0.5 lb. of iron per capita per year. The present annual production of iron for domestic consumption, in the United States, is nearly 600 lb. per capita. The curious state of development of transportation in this interesting country has been a greater handicap upon the mining industry than upon any other. The point upon which it hinges is the absence of a road-system. Except for a few military roads, now almost impassable, there are no roads in China; that is to say, there is no land which is set aside as a right of way, belonging to the commonwealth. Throughout the agricultural districts, generally speaking, the entire area is in private ownership, and the lines of travel are between fields. There is a constant struggle for existence between the owners of the land and the traveling public, with the natural result that the so-called roads usually

* Formerly Professor of Metallurgy, Imperial Pei-Yang University, Tientsin, China.

are simply lines along which it is merely possible to travel. Most merchandise is carried in baskets over the shoulder, pushed in wheelbarrows, or transported on pack-animals, to the nearest stream. Really cheap and efficient transportation is confined to the rivers, and great ingenuity is exhibited in utilizing them to the fullest extent. On the Lan river, for example, the boats, to use an expressive colloquialism, "can float in a heavy dew." The regions where mineral wealth is abundant are naturally but poorly supplied with navigable streams, and it is only where Nature has been so kind as to gather together in one place all the materials necessary for the extraction and reduction of the minerals that any considerable industry has been able to develop. Now railroads are penetrating all parts of the Empire, the streets built in the cities are being extended as roads through the surrounding territory, and the mineral industry is taking on a new aspect.

Theoretically the mineral wealth of the Empire is the property of the central government, and is only worked by permission upon a royalty basis. Practically this is difficult to enforce, and there have grown up relationships between the operators and the government which are complicated in the extreme. The development of the mining industry is correspondingly hampered, and it is to be hoped that a simple and direct code of mining-regulations may be put in force at no far distant date. The importance of the superstitions regarding graves and "Feng-Shui" has been over-emphasized. It has undoubtedly operated to restrict prospecting-work, but where valuable deposits are found it is always possible to have graves moved for a reasonable sum, and it is but seldom that a regard for "spirits" is allowed to operate to financial disadvantage. With the spread of education this factor will lose the limited importance it now possesses.

Easily first in the mineral wealth of China are coal and iron. Willis [54] (reference is to bibliography given at the end of this paper) has estimated that the anthracite-resources of Shansi and adjacent territory are equal to those of Pennsylvania, and while no estimate is possible of the total amount of bituminous coal, it is safe to say that it is also comparable with that of the United States. It is impossible as yet to estimate the iron-resources, for reasons given under the discussion of that metal,

but there is every reason to believe that they are extensive and valuable; some progress has already been made in their utilization on a modern scale. The Empire is the most important producer of antimony, and ranks high in the production of tin. The production of copper and zinc is already appreciable, and the production of petroleum, while as yet small, seems to have much of promise. The production of gold, silver, mercury, and other metals, while worthy of notice, seems to offer less hope of great increase by the introduction of improved methods of working. It will be evident from the following pages that the mineral production of China is at present of no little importance, and her known resources are great enough to offer ground for the belief that considerable development can be expected in the future.

During three years of residence in North China, I visited a large number of districts of which the mineral production is now considerable. It was not possible, of course, to visit all, and for the extreme south and southwestern parts of the Empire I have been dependent upon the statements of others, but especially upon the published reports of the notable group of French explorers and engineers who have extended their study of Indo-China to cover the adjacent areas. The report of Duclos,[13] and that of LeClere,[25] are especially important. Richthofen's monumental work [44] is of permanent value, as is that of the Carnegie Institution exploring party.[53] This latter deals only with general geology, but is of great interest as marking the first attempt to carry on topographic and geologic surveys in China with the precision attained in the United States. A very important paper is that of Willis,[54] who has made an admirable summary of the literature bearing upon the mineral resources of the Chinese Empire.

The bibliography which concludes this paper is not complete, nor has any effort been made to include all references to the subject. All the more important papers are included, but if any have escaped attention the correction will be welcome. Those who have carried on investigation in the Orient will appreciate the difficulty of the work. Important papers have been published in journals that are difficult or impossible to obtain, the native reports are entirely unreliable, and many areas of importance have never been adequately described. In

addition, there is much conflict between reports upon a single area, and often complete disagreement between figures as to present production. The following represents merely as close an approximation to the truth as now seems possible, and will require extensive revision in the light of future development. But having acquired, with much effort, an imperfect knowledge of the mineral resources of this great Empire, it appears a professional duty to place it in a form which may be of assistance to later workers in this broad field. Erroneous statements have probably been included, and it is hoped that the many engineers who have visited China will contribute further data.

In quoting from the reports of others the almost insurmountable obstacle of identification of place-names is constantly met. This is especially true of the French and German authors, whose spellings are often unrecognizable. Wherever possible I have given the latitude and longitude of the localities mentioned, except in the case of well-known places. Even this is unsatisfactory, for the most accessible accurate maps of southwestern China are French and the longitude is given in degrees east of Paris, which is approximately 2° 20′ east of Greenwich. The French notation has been followed in the case of points in Ssu-chuan, Yunnan, and Kweichou. This should be borne in mind in consulting the maps. In some cases where the spelling is obviously incorrect, or it has been impossible to identify the places, I have placed them within a semi-quotation mark 'thus,' and turned over the difficulty to the reader.

For convenience, reference is made by number in the text to the bibliography given at the end of the paper; [43] is a good geography of the Empire and [8] is a fairly complete bibliography of China.

II. Coal.

Coal is easily the first of the mineral resources of China. The great extent of the deposits has already been indicated and a conservative estimate of the present production is 15,000,000 tons annually. The casual visitor to North China, where the winter climate is rigorous, seeing the children of the villagers, armed with rake and basket, engaged in collecting every scrap of vegetable material that can be utilized as fuel, is likely to wonder why coal is not more generally used.

The reason is not recondite: the low cost of labor, the high cost of transportation, and the low scale of living put coal beyond the reach of the population in many regions. It is probably safe to estimate that one-half the cost of the food of an ordinary workman is chargeable to the fuel used in cooking it, and where the otherwise unemployed children can be sent out to gather grass and pull up the roots of the larger cereals, such as corn and *kao-liang*, there is little market for coal, except for industrial purposes. Near the mines, where coal is abundant and cheap, it is freely employed. The development of railroads, steamships, and industrial plants will not only create a greater market for coal, *per se*, but, by raising the scale of living through the higher wages paid for labor, will increase the consumption of coal for household purposes. The annual consumption of coal in the United States is approximately 3.5 tons per capita per annum; the consumption in China is approximately 1/25 ton per capita per annum. An approximate estimate of the present coal-production in China is given in Table I.

TABLE I.—*Approximate Estimate of the Present Coal-Production of China.*

Province.	Anthracite.	Bituminous.	Sub-Bituminous and Lignite.
	Tons.	Tons.	Tons.
Manchuria	....	25,000	1,000,000
Chili	840,000	2,090,000	150,000
Shansi	4,000,000	25,000	
Shensi	....	500,000	
Kansu	....	500,000	
Shantung	300,000	500,000	
Honan	1,000,000	....	
Ssu-chuan	....	500,000	
Kweichou	....	250,000	
Yunnan	....	300,000	
Chekiang	....	10,000	
Kiangsi	....	700,000	
Hunan	....	200,000	
Kuangtung	....	50,000	
Kuangsi	....	100,000	
Other provinces	....	100,000	
Total	6,140,000 5,900,000 1,150,000	5,900,000	1,150,000
Grand total	13,190,000		

The sketch-map, Fig. 1, shows in general the coal areas of China. This map, as well as Fig. 2, has some misspelled names, as it was impossible to arrange for revision of the proofs.

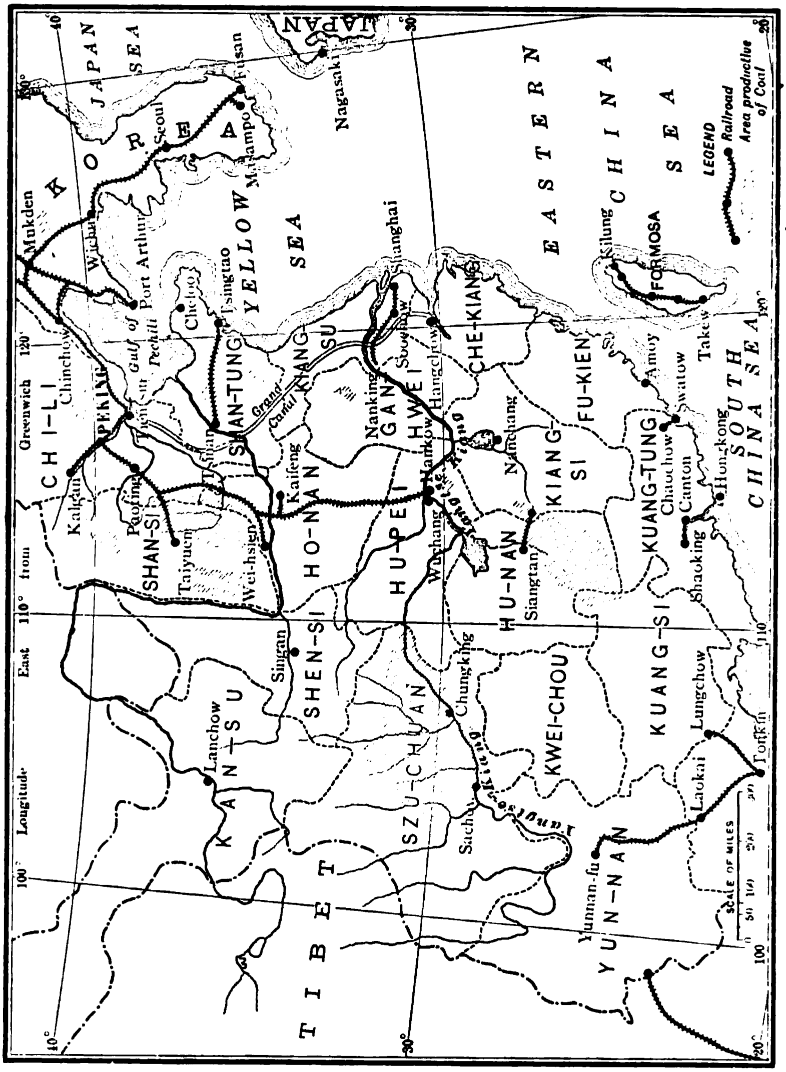


FIG. 1.—MAP OF CHINA, SHOWING COAL-AREAS.

The coals of China are as varied in quality as those of the United States, but this difference should be noted: the amount of lignite is comparatively small, and the proportion of anthracite to bituminous is relatively larger than in the United States. As previously noted, Willis has estimated that the anthracite-

resources of Shansi and the adjacent fields are practically equal to those of Pennsylvania. If this is in error it is probably upon the safe side, and the total coal-resources of the Chinese Empire seem likely, upon careful mapping, to compare favorably with those of the United States.

In the space at my command it would not be possible to give

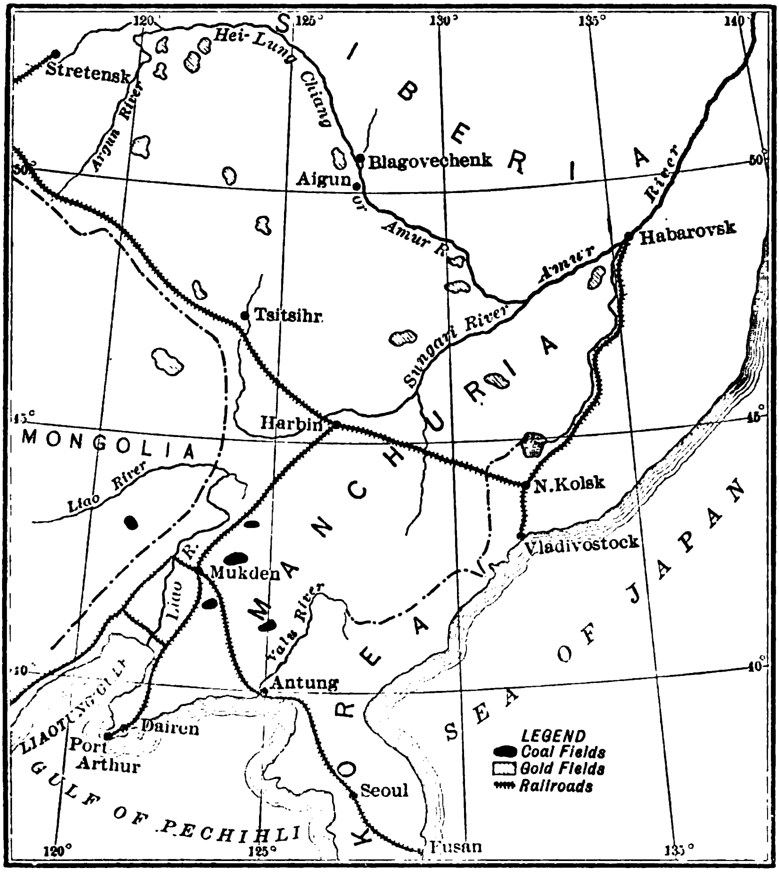


FIG. 2.—COAL-FIELDS AND GOLD-FIELDS OF MANCHURIA. (AFTER PURINGTON.)

more than a brief outline of each of the important fields. The number of fields is so great that an attempt at classification would lead to too great complexities, and it will be simplest to consider them briefly by provinces.

In Manchuria one large mine is now in operation at Fushun. This field, seen just above the word "Mukden" on the sketch-

map, Fig. 2, has been described in detail, [28], [30], so nothing further will be given here than to state that the coal is a sub-bituminous of excellent quality. The mines, owned and operated by the South Manchuria railway, had a production in 1910 of 830,328 tons, and are expected to reach 1,000,000 tons per year when the second of the two pairs of deep shafts (18 and 20 ft. in diameter) are in full working-order. More recently the mines at Pen-hsi-hu, on the Antung-Mukden railway, have been developed; but, although I passed through the town in the autumn of 1910, I have been unable to obtain figures as to the production, which is probably small as yet, but is likely to develop when the standard-gauge line between Mukden and Antung is in operation. The chief engineer at Fushun stated in 1909 that the Pen-hsi-hu coal is a friable semi-bituminous, occurring in Jurassic strata, and not of especially good grade, but more extensive development may have disclosed seams of better quality. The same remarks will apply to Sai-ma-chi (125° E., 41° 30′ N.); owing to its distance from the railroad no very serious attempts have been made to develop these mines. All mines in the South Manchuria railway zone are to be developed jointly by Japanese and Chinese.

Just east of Kwan-cheng-tze (125° E., 44° N.), coal similar to that at Fushun occurs in several places, and though the attempts at working have not been very successful as yet, the seams at this place are likely to become of great importance, as the branch railroad to Kirin cuts directly across them. West of the Liao river (somewhere about 122° E., 43° N.) a valuable and important field is said to exist, but I have not visited the locality and have no definite knowledge of it. Some time since the Imperial Railways of North China attempted to exploit some seams of a true lignite a short distance north of the Great Wall, but they proved to be of too poor quality. Other localities where coal occurs are Yentai and Wu-hu-tsui, but the production is unimportant. Thin seams of coal can be seen in the cuts along the trans-Siberian railroad, and the Bureau of Mines for Manchuria has published a long list of places where coal occurs in Manchuria. The coals of the southern part of the province were described by K. Inouye in 1905.[20a] Coal occurs widely throughout the area; that at Fushun and near Kwan-cheng-tze is sub-bituminous and of Tertiary

age; in the other districts the coal is semi-bituminous and of Jurassic age. No closer classification can be attempted as yet. The native consumption is generally supplied by small local mines. The South Manchuria railway and a considerable portion of the shipping-trade of Dalny (Tairen) are supplied by the Fushun mines. As the workable coal in the Fushun field has been estimated at 800,000,000 tons, Manchuria is well supplied with coal. But the Manchurian coals are very friable, furnishing but a small proportion of lump-size, and no good coking-coal has yet been found. The composition of the coals of Manchuria is given in Table II.

TABLE II.—*Analyses of Manchurian Coals.*

No.	Locality.	Moisture.	Volatile Hydrocarbon.	Fixed Carbon.	Ash.	Sulphur.	Analyst.	Remarks.
		Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.		
1	Fu-shun........	6.30	39.34	52.90	3.18	0.27		Average of 7 published analyses.
2	Fu-shun........	4.43	40.33	48.89	6.35	1.00	C. H. Wang	
3	Wu-hu-tsui...	2.70	11.42	76.69	9.19	0.50	Geological	
4	Pen-hsi-hu...	0.96	21.66	66.06	11.32	0.84	Survey of	Average of 3 published analyses.
5	Yen-t'ai.........	1.07	14.22	74.98	9.75	0.66	Japan.	Average of 3 published analyses.
6	Sai-ma-chi....	1.39	25.58	60.47	12.25	0.80		Average of 3 published analyses.

Chili, which immediately adjoins Manchuria on the southwest and is the metropolitan province, is now the most important producer of coal, as can be seen from Table III., which gives a summary of the coal-output of Chili province for 1909 by K. Y. Kwong, chief mining engineer for the Chili Province Bureau of Mines, Tientsin. The composition of some Chili coals is give in Table IV.

TABLE III.—*Production of Coal in Chili Province for* 1909.

Lignite.

		Tons.
Jehol district (118° E., 41° N.) coal-fields.........	Yen-pao-shan, Wo-chia-tze, Shih-t'ou-fen,	150,000
Total lignite..		150,000

Anthracite Coal.

Kin-Han railway district coal-fields..................	Tai-an, Fangshan-hsien (116° E., 39° 45′ N.), Sha-ho-hsien (114° 40′ E., 37° N.), Lin-ming-kwan, Han-tan-hsien,	600,000
Peking-Shanhaikwan railway district coal-field,	Shi-men-tsai,	50,000
Peking-Kalgan railway district coal-fields.........	Sin-pao-an,.....................	20,000
	Peking Western Hills (115° 45′ E., 40° 15′ N.),	150,000
Total anthracite...		840,000

Bituminous Coal.

Peking-Shanhaikwan railway district coal-fields.........................	Kaiping { C. E. & M. Co., Ltd., mines, Lanchow mines,	1,400,000
Kin-Han railway district coal-fields....................	Lingshan,.......................	50,000
	Ching-hsing (114° E., 38° N.),......................	160,000
	Lincheng (114° 30′ E., 37° 30′ N.),................	100,000
	Tze-chow (114° 20′ E., 36° 30′ N.),................	100,000
Peking-Kalgan railway district coal-fields.........	Hsuen-hua-fu (115° 10′ E., 40° 50′ N.),	40,000
Lan-Ho and Jehol districts coal-fields...........	....	100,000
Chow-yang-fu coal-fields..		140,000
Total bituminous coal....................................		2,090,000

TABLE IV.—*Analyses of Some Chili Coals.*

No.	Locality.	Moisture.	Ash.	Fixed Carbon.	Volatile Hydrocarbon.	Sulphur.	Fixed Carbon Ratio.	Analyst.	Remarks.
		Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.			
1	Tongshan,C.E.& M.Co.	1.00	16.67	56.78	25.55	1.01	2.22	C. H. Wang.	Coking, bituminous.
2	Tongshan,C.E.& M.Co.	0.84	18.02	57.19	23.95	1.46	2.38	C. H. Wang.	Bituminous.
3	Tongshan,C.E.& M.Co.	1.37	21.72	53.81	23.10	2.55	2.38	C.H. Wang.	Non-coking, bituminous.
4	Tongshan,C.E.& M.Co.	0.93	12.29	59.75	27.03	3.90	2.21	C. H. Wang.	Coking, bituminous.
5	Tongshan,C.E.& M.Co.	0.90	13.55	70.33	15.22	2.26	4.62	C. H. Wang.	Coking, bituminous.
6	Tongshan,C.E.& M.Co.	0.77	18.59	53.28	27.40	1.11	....	Average company	analysis furnished by
7	Linsi, C. E. & M. Co....	0.77	19.18	51.97	28.05	0.88	....	Average company	analysis furnished by
8	Ching-Hsing...............	0.54	13.49	61.16	24.81	2.26	2.46	C. H. Wang.	Coking, bituminous.
9	Chai-t'ang.	2.11	6.67	68.23	22.99	0.19	2.97	C. H. Wang.	Non-coking, bituminous.
10	114° 30′ E., 38° 45′ N....	1.20	12.97	80.50	5.43	0.97	14.81	C. H. Wang.	Hard, dry anthracite.

The lignite and bituminous coal of the Jehôl district is produced by native methods, the nature of which can be inferred from the photographic views, Figs. 3 and 4, taken in the

Western Hills. The Kin-Han (Peking-Hankow) railway district anthracite-field and the Peking-Kalgan railway district field are northern and southern portions of one field lying a short distance west of Peking. Hoover [17] and Woo [56] have described the Chinese Engineering & Mining Co. mines at Tongshan and Linsi in detail. These are the largest and most important coal-mines in China. They are owned by an English company, but it has been proposed by the gentry of the province that the concession be purchased by the Provincial government. Since the descriptions were written, the mines have been much developed and improved. They produce nearly all of the total of the 1,400,000 tons estimated above, as the semi-official Lanchow mines, in the same field, have only recently been started and, though well equipped, seem unable to operate at a profit. The net profit of the Chinese Engineering & Mining Co. mines for the year ending February, 1910, is given as £243,300. The Ching-Hsing mines, on the railroad from Shih-chia-chuang to Tai-yuan-fu, are worked under German supervision, and have both Chinese and German capital. The production in 1910 was 150,000 tons. The Lincheng mines are operated to supply the Kin-Han railway with fuel, and are under the supervision of K. Y. Kwong. They have an output of 800 tons per day. The coal-field at Tze-chou has been described by Drake.[10] The mines at Hsuen-hua-fu have only recently been opened to supply the Peking-Kalgan railway with fuel, and their production will probably increase considerably during the next few years; there is already a considerable production by native methods in this and adjacent districts. It is obvious that it would be possible to devote much space to a description of the mines of this one province, but they are so accessible and comparatively well known that, in spite of their great importance, I shall not discuss them further. The analyses in Table IV. show the characteristics of these coals, and it will at once be noticed that they grade by degrees from bituminous into anthracite.

In Shantung coal occurs in many places, but the larger part of the production comes from the mines owned by the Shantung Bergbau Gesellschaft, at Po-shan (118° 0′ E., 36° 45′ N.) and Fang-tze; 252,816 tons of anthracite coal having been produced at the former place in 1910, and 230,064 tons of

bituminous at the latter. These mines have washing-plants. Some difficulty has been found in working, owing to the faulting and disturbance of the beds, and the native papers say that there is little profit in their operation. In this, as in every other coal-field in China, there is a large amount of native mining upon a small scale. Farther to the southeast, near Yi-hsien (118° 36′ E., 35° 0′ N.), is a bituminous field which is said to be larger and better, but which I have not visited. The production of the native mines is already important. A large native company, called the Chung Hsing Kung Ssu, has been formed, machinery procured from Germany, and a railroad constructed from the mines 35 miles to the Grand Canal. This will probably be extended to connect with the Tientsin-Pukou railroad, and when the latter road is in operation the production of coal in this district should become important.

Much has been written concerning the coal-fields of Shansi, and having spent some time in visiting the more important localities, the temptation is strong to describe them fully. But since others, [12], [54], [44], [45], have discussed them in more or less detail, I shall only refer to them briefly. These anthracite-seams are the most striking coal-beds in the Empire, as they are so thick, so little disturbed, so well exposed, and so widely distributed, having an extent of nearly 200 miles north and south, and from 25 to 30 miles east and west. There are several seams, one of which is especially thick and persistent. Richthofen [44] estimated the area of the field as 13,500 sq. miles, and Drake [12] estimated the average workable thickness of the seams as 22 ft. As the beds are frequently but slightly inclined, this corresponds to a yield of over 22,000,000 tons per square mile of workable area, so it is safe to estimate that the anthracite-resources of this part of China are at least equal to those of the United States. Mining in this field is under the control of the Pao-Chin Mining Co., which was formed by the gentry of the province to repurchase the concession of the Peking Syndicate. Several shafts are making a small production, most of the present output coming from native workings. The area controlled by the Pao-Chin Mining Co. is of immense importance, and it is to be regretted that so little progress is being made. There were, in 1910, no trained engineers in the employ of the company, though there are numbers

of properly qualified Chinese engineers available. The analyses given in Table V., most of which were made by C. H. Wang, exhibit the character of the coals. An interesting feature is the high content of phosphorus, and the importance which this has had in the native metallurgy of iron is discussed in the section devoted to that metal. Shansi also possesses considerable resources in bituminous and semi-anthracite coal, which is produced both to the east and west of Tai-yuan-fu and sold in considerable quantity in that city. Analyses are given in Table V.

TABLE V.—*Analyses of Shansi Coals.*

No.	Locality.	Moisture.	Volatile Hydrocarbon.	Fixed Carbon.	Ash.	Sulphur.	Phosphorus.	Analyst.	Sp. Gr.	Remarks.
		Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.			
1	Chuang-chuang-kou,	0.91	8.20	78.75	12.14	0.67	0.476	C.H.Wang.	....	Semi-anthracite, does not coke.
2	Hon-ho-kou..............	0.94	6.15	85.70	7.21	0.59	n. d.	C.H.Wang.	....	Hard dry anthracite.
3	Han-ho-kou..............	0.38	8.55	84.00	6.72	0.409	0.23	F. N. Lu.	1.38	
4	Tuan-chia-kou..........	0.76	6.44	79.10	13.66	0.683	1.80	F. N. Lu.	1.35-1.38	
5	Lao-hsien-shêng-kou,	0.66	4.49	89.50	5.46	0.509	2.53	F. N. Lu.	1.4	
6	Nan-t'ien-mêng.........	2.01	7.05	81.35	9.61	0.867	n. d.	F. N. Lu.	1.3-1.5	
7	Meng-tsen-chêng.......	0.33	4.39	89.25	6.03	0.405	2.15	F. N. Lu.	1.8 high	
8	Chuang-chuang-kou,	14.75	19.28	52.42	13.45	0.890	n. d.	F. N. Lu.	Coked in crucible, probably due to oxidation.	
9	Chang-tsai-kou..........	0.50	14.20	75.89	9.41	0.258	n. d.	C.H.Wang.	....	Semi-bituminous, coked in crucible.
10	Tung-chia-chuang.....	1.73	10.72	84.22	3.33	1.150	n. d.	C.H.Wang.	....	Semi-anthracite, does not coke.
11	....	1.93	3.45	81.44	14.17	0.35	n. d.	....	Average of 6 analyses by Drake.[12]	
12	....	2.91	86.80		9.88	0.41	n. d.	....	Average of 6 analyses by Shockley.[47]	

Samples 1 to 8 were taken throughout the district (113° 30′ E., 38° N.); sample 9 from (112° 40′ E., 37° 55′ N.); and sample 10 from (112° 40′ E., 37° 50′ N.).

In Shensi, which adjoins Shansi on the west, extensive coal-fields are known to exist, and Richthofen,[44],[45], thought that the bituminous-fields to the west of Tai-yuan-fu were of equal extent and importance as the anthracite-fields to the east. This is possibly too optimistic, but they are certainly very great. I have estimated the production of this province as 500,000 tons, but this is problematical, as the area is so little known. The same remarks apply to Kansu, which adjoins Shensi on the west. I have, for this reason, omitted Mongolia from Table I., on page 297, though it is known to possess coal-seams in

those portions which adjoin Chili and Shansi. Passing directly south, to Ssu-chuan, Kwei-chou, and Yunnan, our knowledge is in a similarly unsatisfactory state. Richthofen,[45] who only traversed the northeastern part of Ssu-chuan, says, in substance, that coal is very generally worked throughout the province, as the Mesozoic strata are extensively folded and are cut across by the rivers, thus conveniently exposing the seams. So far as I can learn, the coal here is not of as good quality as other deposits more favorably situated with respect to the larger markets, which, together with the difficulties of transportation on the Yangtze, restricts production to the amount required for local needs. A few years ago, a British company secured a concession at Wan-hsien (108° 30′ E., 31° 0′ N.) and installed modern machinery, but it has now been handed over to a native company and is worked by native methods. Baber,[1] Hosie,[18] Duclos,[13] LeClere,[25] and others have noted many places where coal is worked in Ssu-chuan. Duclos has discussed at some length the occurrence and methods of working coal in Ssu-chuan; his remarks are best summarized by a quotation from his report: "Le charbon se trouve presque partout dans le province, donnant lieu à de petites exploitations qui subviennent aux besoins locaux." LeClere,[25] who has a favorable opinion of the coal-resources of southwestern China, says that coal occurs at four horizons, from lower Palæozoic to Rhétic, and is widely distributed over a quadrilateral area bounded by 'Lao-Kay' (101° 31′ E., 22° 30′ N.), 'Yunnan-hsien' (100° 30′ E., 23° 0′ N.), 'Tchao-toung' (101° 31′ E., 27° 30′ N.), and 'Kouei-Yang-hsien' (104° 20′ E., 26° 20′ N.). He thought that the field most favorable for exploration is that lying to the west of Mengtze (101° 0′ E., 22° 45′ N.). Duclos [13] mentions four places in Kwei-chou where coal is produced; 'Mao-py', 'Tchen-lin' (103° 15′ E., 26° 0′ N.), 'Choui-tang-pou', and Ma-lou-kio (102° 27′ E., 26° 58′ N.).

The anthracite-field of Shansi extends southward into Honan province and at Ching-hua-hsien, 113° 40′ E., 35° 15′ N. approximately, the Peking Syndicate has several shafts, equipped with modern machinery, in operation. This company has had a good many vicissitudes, but is now meeting with success; the production during 1910 is given as 357,205 tons. There is a good deal of production by native methods in this province.

The great southern coal-field lies to the east of the Hsiang river, in Hunan and Kiangsi provinces. The greater part of the field is in the former province, but the most important producer, the collieries of the Han-Yeh-P'ing Iron & Coal Co., are at P'ing-hsiang (113° 50′ E., 27° 30′ N.), in Kiangsi. A view of the P'ing-hsiang colliery, showing two banks of coke-ovens and the washing-plant, is given in Fig. 5, and a nearer view of one bank of ovens is shown in Fig. 6. The steel head-frame of the shaft is shown in Fig. 7. This coal is a bituminous coking variety (with associated thin seams of anthracite), which contains 28 per cent. of ash as mined, but after washing and drying an average analysis furnished by the company gave:

	Per Cent.
Volatile hydrocarbons,	22.35
Fixed carbon,	68.90
Ash,	8.70
Sulphur,	0.10

It yields excellent coke, which supplies the blast-furnaces at Han-Yang and the general market; more than 107,000 tons having been produced in 1909. Further details can be found by consulting [37] and [48]. The production for 1910 is given as 610,000 tons. The coal-fields extend west and south from this point for a great distance, and Richthofen [45] says that southward the coal is anthracite and of better quality. Transportation is difficult, owing to the shallowness of the rivers; so development has lagged; but when the Canton-Hankow railway, now under construction, is in operation, this field, which I regard as only second in importance to the Shansi field, is likely to develop greatly. Some of the most important mineral regions in China lie to the west of the projected railway-line, and the transportation-facilities thus afforded should lead to a great increase in mineral production.

The coal-fields of Chekiang are of little importance. In Kwangtung and Kwangsi coal is mined at a number of places, but I have no personal knowledge of this area. My impression that these coal-deposits are worked because of their proximity to important centers of trade, rather than because of their superior quality, is not improbably correct.

Despite the importance of the coal-fields of China, it is impossible to afford more space to their discussion. Reference should

be made to the papers quoted for further details. In conclusion, it should be said that the coal-fields of China are of great extent, the coal is generally of good quality and the fields are widely scattered, so that no parts of the Empire are far distant from the sources of supply. In extent and quality the coal-resources of the Empire compare favorably with those of the United States. As a rough comparison, it may be said that Chinese coals are slightly younger than those of North America, most of the fields being upper Carboniferous or Permian. In the north, Jurassic and Tertiary coals occur, but except for the Fushun field, are of little importance as yet. There has been a good deal of controversy over the exact age of these coals, but it is of little interest to mining engineers. Bituminous coking-coal is very common; coke made by native methods can be obtained almost anywhere in the Empire. When made from washed coal, the resulting coke is of excellent quality, and will afford an abundant supply for the smelting-industries which are likely to develop. The anthracite is of excellent quality, but the bituminous is often friable, yielding an excessive proportion of fine coal. When worked on a large scale this can be washed and converted into coke. The Chinese custom is to make the dust into briquettes with clay as a binder, which are dried and burned. In recent years the number of mines equipped with modern machinery has become comparatively great, and the present supply amply meets the demand. The mines of the Fushun Co. and the Chinese Engineering & Mining Co. now chiefly supply the railway- and shipping-trade of North China, because of the superior transportation-facilities which they enjoy. These two companies also send coal to the cities along the SE. coast, competing with Japanese coal. Coal-production throughout China exhibits a healthy and vigorous growth. The annual production of the Empire, as shown in Table I., is estimated at 15,000,000 tons; but this amount is only approximate. The amounts given for Yunnan and Ssu-chuan, for example, should be designated as guesses rather than estimates, and the figures occasionally seen in statistical tables giving the production of the Empire to the nearest thousand tons are totally misleading in the false appearance of accuracy which they present.

FIG. 3.—MOUTH OF A COAL-MINE WORKED BY NATIVE METHODS. THE SMALL BOY ILLUSTRATES THE SIZE OF THE OPENINGS.

FIG. 4.—BASKETS USED IN TRANSPORTING COAL FROM WORKING-FACES TO PIT-MOUTH IN MINES WORKED BY NATIVE METHODS.

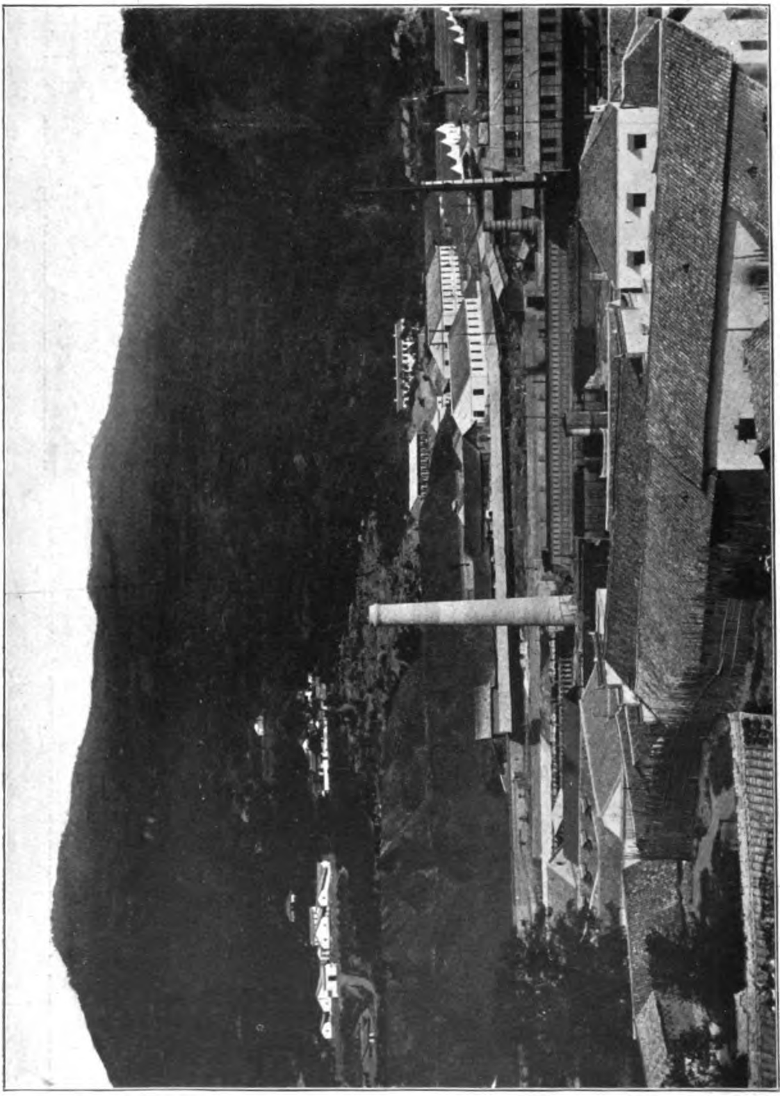


FIG. 5.—P'ING-HSIANG COLLIERY, KIANGSI.
TWO BANKS OF COKE-OVENS IN FOREGROUND, WASHING-PLANT TO RIGHT.

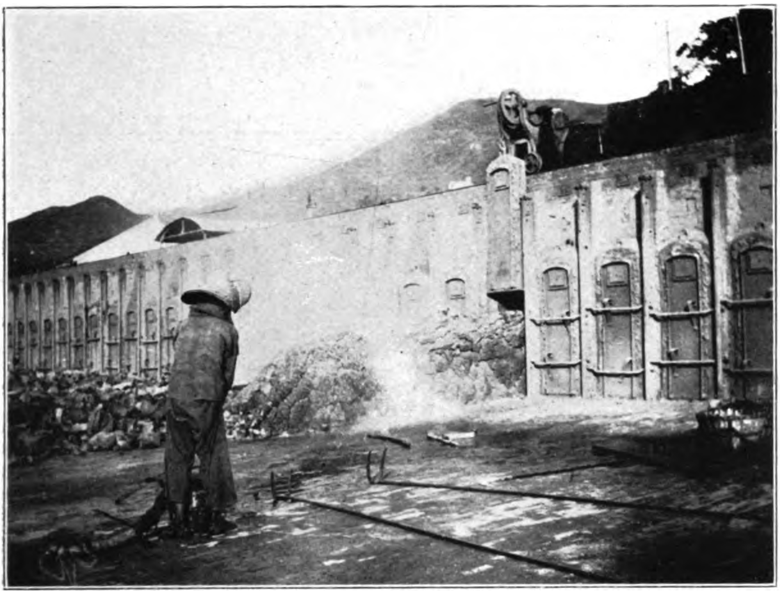


FIG. 6.—COKE-OVENS, P'ING-HSIANG COLLIERY, KIANGSI.

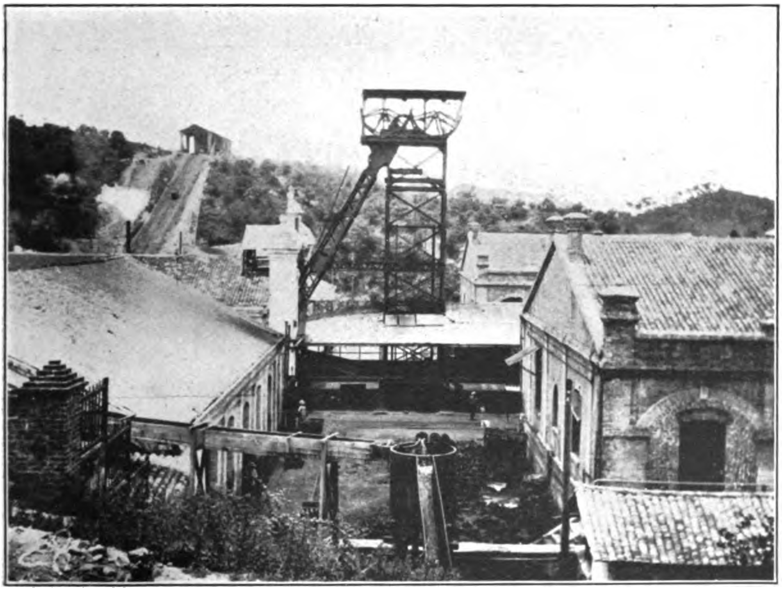


FIG. 7.—HEAD-FRAME, P'ING-HSIANG COLLIERY.

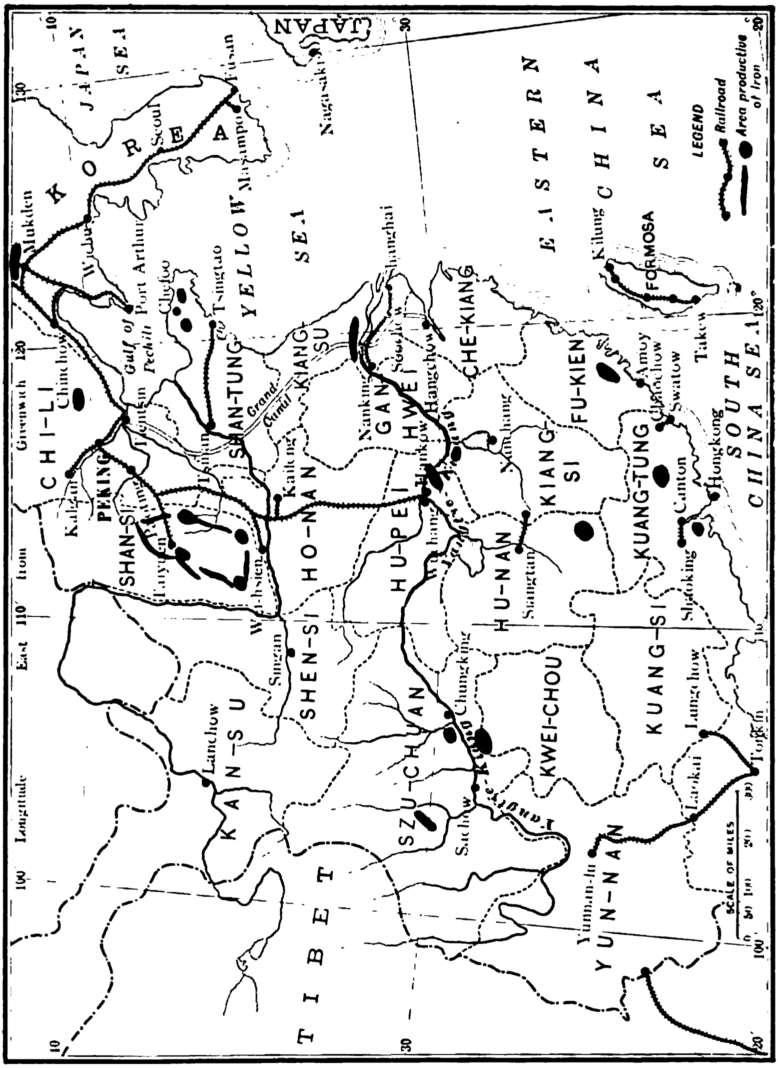


FIG. 8.—MAP OF CHINA, SHOWING IRON-ORE CENTERS.

FIG. 9.—HOISTING IRON-ORE FROM A SHALLOW CIRCULAR SHAFT, NORTH OF P'ING-T'ING CHOU, SHANSI.

FIG. 10.—A BATTERY OF CRUCIBLES REDUCING IRON-ORE, SHANSI. WHEN THE FRONT HAS BEEN CLOSED IT WILL BE READY TO LIGHT.

FIG. 11.—FURNACE FOR REMELTING THE PIG-IRON FOR CASTING, SHANSI. THE UNUSED CRUCIBLES ARE ON THE BOTTOM AND PILED AT THE BACK, USED CRUCIBLES ARE SEEN AT THE SIDE; THE BLOWING-APPARATUS IS AT THE BACK.

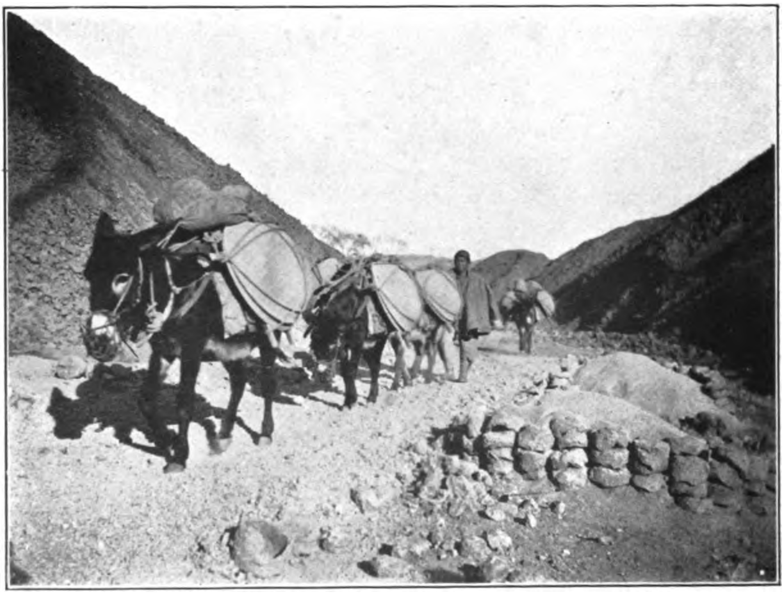


FIG. 12.—TRANSPORTING *Kuo* (CAST-IRON PANS) TO MARKET. CLAY FOR CRUCIBLES IS PLACED IN THE ROAD TO BE PULVERIZED BY THE MULES. THE HEAPS ON EACH SIDE ARE WASTE FROM THE SMELTERS.

III. Iron.

Iron is the second in importance of all the mineral resources of China, and the security of the future of China as a mineral-producing nation is easily appreciated, since it is founded upon an abundant supply of coal and iron, the two bases of industrial development. In the case of other minerals it may be inferred, without falling into serious error, that practically every occurrence of importance has been worked, to a slight extent at least, by native methods. But this is not true of iron-ore deposits. The great importance of the lack of transportation-facilities upon the development of mineral wealth has already been mentioned, and it is in the case of iron that its influence has been most marked. In the native method of iron-smelting such large quantities of coal are used that it is necessary to have both coal and iron-ore in close proximity in order to permit the development of a smelting industry. This condition obtains in several provinces, but most notably in Shansi, where it has been described by Richthofen, [44], [45], and Shockley.[47] But while these deposits are adapted to the native methods of working, they are not at all suited to modern methods, where a large supply of iron-ore of uniform quality and high iron-content is necessary. It is reasonably certain that such deposits exist in numerous places; but, except in the case of the Ta-yeh mine, to be described later, they have not yet been developed because the necessary supply of coal does not exist near-by. A sketch-map showing the iron-centers in China is given in Fig. 8. A description of the deposit at Ta-yeh will be given, followed by a list of the principal localities throughout the Empire where iron-ore is known to occur. I will preface this by a description of the P'ing-t'ing-chou district in Shansi, the principal one in which iron is produced by native methods. The accounts of this by Richthofen have already been mentioned; what is here given, however, is based upon notes made during the winter of 1910. The analyses given of the raw materials and products have been made by my former students, C. F. and C. H. Wang and F. N. Lu.

The iron-ores of Shansi are limonite and hematite, occurring in shales and sandstones of Carboniferous age; the varieties of method of occurrence are so numerous that to attempt their

description would require too much space. Usually they are in masses of no great size, commonly in or near a disturbed zone in the strata, or else in beds or flat veins, from a few inches to not more than 3 ft. thick, of limited extent. It follows, therefore, that no sufficient supply of uniform enough quality can be obtained from the Shansi deposits, so far as yet explored, to form the basis of blast-furnace work on a large scale. More recently it has been reported that on the southern border of this district, in Honan province, a suitable deposit has been found, and it has been proposed to erect there another government iron-works, similar to the one described later. Two analyses of the ore from T'ai-yang, near Tze-chou-fu, as given by Shockley,[47] are shown in Table VI.

TABLE VI.—*Analyses of Iron-Ore from T'ai-Yang.*

	I.	II.
Fe	53.88	45.50
SiO_2	4.67	11.15
Al_2O_3	3.46	6.42
MnO_2	0.57	0.51
CaO	2.21	5.50
MgO	trace	0.25
P_2O_5	0.57	1.08
S	0.074	0.016
CO_2	9.37	2.70
H_2O	2.20	7.35
Analysts,	Edward Riley.	Pattinson and Stead.

The ore, mined through shallow round or rectangular shafts, Fig. 9, is broken into small pieces and hand-sorted into several grades, which are sold to the smelting-plants. Here it is mixed with 50 per cent. of its volume of coal and packed into cylindrical crucibles, 5 in. in inner diameter, and usually 45 in. high, Fig. 10. From 250 to 275 of these crucibles are set upright in a rectangular furnace, about 12 by 6 by 4 ft. Air-space is secured at the bottom by a layer of broken crucibles, over which is placed a layer of coal; then the crucibles are set in place, with coal between them; the front side is closed, the whole is covered over with coal and allowed to burn by natural draft for three days. The crucibles are then removed and the contents taken out. This operation usually involves breaking the bottom part of the crucible, which now contains an irregular "bloom" of iron of very variable composition (Table VII.),

irregular fragments of iron, earthy residues, and a certain amount of coke. The bloom is sold to the makers of wrought-iron, the small pieces of iron are sold to the makers of cast-iron, and the coke is used in the manufacture of crucibles. It should be noted that the product of this method ot melting is not pig-iron, in the ordinary sense of the word, as it contains very little carbon, and is malleable. The bloom is worked into wrought-iron by heating in a wood fire and hammering until it is worked down into a rectangular ingot, which is then sold, and either manufactured locally into various objects and utensils, or shipped in the ingot form to all parts of the Empire. The small pieces of iron are mixed with coal and placed in crucibles, about 7 by 14 in., and from 50 to 80 of these are placed in a smaller furnace, Fig. 11, blown by hand. When the iron is melted the covering of the furnace is removed, the crucibles are taken out, the contents of several crucibles are poured into one, and this is then poured into molds, which have previously been prepared with extraordinary skill. In this way various cooking-utensils, especially *kuo*, are cast, often of remarkable thinness, as the castings contain as much as from 5 to 7 per cent. of phosphorus, which has been taken up from the coal during the reduction and remelting.

TABLE VII.—*Average Phosphorus- and Sulphur-Content of Native Pig-Iron of P'ing-t'ing-chou, Shansi, China.*

Sample No.	Locality.	Phosphorus.	Sulphur.	Remarks on Samples.
		Per Cent.	Per Cent.	
1	Li-chia-chuang......	1.7314	0.5489	Clean, malleable.
2	T'ao-p'o.....	0.4671	0.1781	Dirty, malleable.
3	Yang-chia-chuang..	4.8400	0.4577	Rather clean, brittle.
4	Nan-yao-kou.........	2.6066	0.2486	Dirty, globular.
5	Chien-mu-p'ing.....	0.8527	0.1254	Dirty, porous, brittle.
6	San-ch'uan...........	0.6854	0.1365	Clean, porous, brittle.
7	Yang-shu-kou........	1.5075	0.6140	Dirty, porous, slightly malleable.
8	San-tu..................	0.4645	0.4945	Dirty, porous, slightly malleable.
9	Ing-Ying...............	3.5700	0.6375	Clean, hard, massive.
10	Han-ho-kou..........	3.7645	0.2999	Clean, hard.
11	Wu-tu..................	0.7315	0.2155	Clean, malleable.
12	Yang-chü Hsien ...	6.9540	0.2196	From a cast-iron bar.
	Average.......	2.3479	0.3480	

Analyses by Cheng-Fu Wang.

Note in Table VII., sample No. 12, the high percentage of phosphorus in the cast-iron bar. It is not at all improbable

that the high phosphorus-content of the Shansi coals, Table V., samples Nos. 5 and 7, has been the chief factor in the great development of the industry, as it has afforded an easy means of securing the high-phosphorus iron necessary in making thin castings. Fig. 12 shows the method of transporting cast-iron pans, *kuo*, to market; the heaps on each side of the road are waste products from the smelter; and the road between is filled with lumps of clay. Formerly the iron-products of this locality found their way through the channels of trade to nearly all parts of the Empire. Now the trade in native iron exists chiefly in the interior, as foreign scrap-iron and steel, especially old horse-shoes, are imported in large quantities into all the treaty-ports; and because of their superior quality and low price tend to drive out the native product. The native industry, therefore, is steadily dwindling, though it will continue to exist until foreign cooking-utensils displace the high-phosphorus cast-iron *kuo*. Shockley [47] has called attention to the amount of decrease between the time of Richthofen's visit and his own. Table VIII. gives the production, as estimated by Shockley, of the chief districts of Shansi in 1901.

TABLE VIII.—*Annual Production of Native Iron in the Chief Districts of Shansi.*

	Tons.
Yu-hsien,	4,500
P'ing-ting-chou,	18,000
Yiu-ch'eng,	6,000
Kao-p'ing-hsien,	4,000
Tse-chou-fou,	13,333
Yang-ch'eng,	2,000
Ch'in-shui,	1,415
Tai-yuan-fu,	2,000
Total,	51,248

The following notes of the only modern steel-works existing in China at present were made during a visit to its iron-mines and metallurgical plant during the summer of 1908.

The blast-furnace and steel-plant of the Han-Yeh-P'ing Iron & Coal Co. is situated at Hanyang, just across the Han river from Hankow, in Central China. Its iron-ores are mined at Ta-Yeh, about 50 miles SW., and its coke is obtained from its colliery of P'ing-hsiang, in Kiang-si province, more than 300

miles distant. The relative positions of the properties are shown on the sketch-map, Fig. 13.

The iron-ores at Ta-Yeh occur about 15 miles west of the Yangtze river, and lie along the contact between a marble and an intrusive body of a dark gray syenitic rock, Fig. 14. There is no direct evidence in the neighborhood as to the age of the

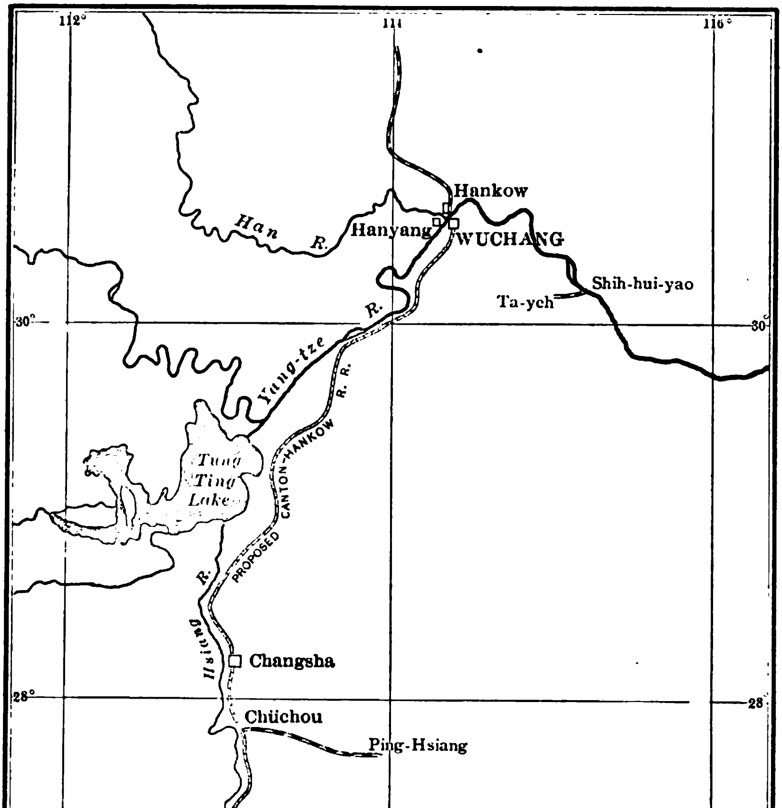


Fig. 13.—Sketch-Map Showing the Relative Positions of the Properties of the Han-Yeh-P'ing Iron & Coal Co.

marble, but on lithological grounds it seems identical with the limestone occurring near Nanking, which Richthofen [45] has called the 'Sihia.' (He has translated the Chinese characters incorrectly; it is properly 'Hsi-hsieh.') Richthofen has suggested the age as Devonian, but the closely-associated coal in

both localities makes it much more probable that it is rather to be regarded as Carboniferous, since the Devonian is generally very poorly developed in China. There is much doubt as to exact correlation of China fossil fauna with that of other countries, and in nearly all cases coals in China belong to the Carboniferous, or the immediately overlying series. If these two are identical, it would then appear that this limestone is a horizon for iron-ores in the Yangtze valley, as they are associated with it in notable amount near Nanking, as will be noticed later.

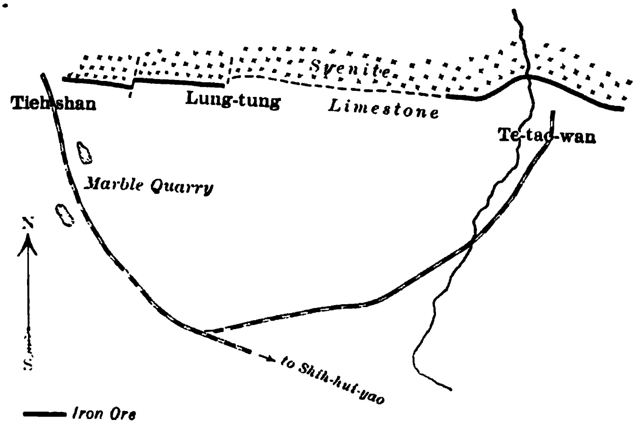


FIG. 14.—IRON-ORE DEPOSIT AT TA-YEH.

The ore is a good quality of hematite of about the following range of composition, furnished by the Han-Yeh-P'ing Iron & Coal Co.:

Iron Ore, Ta-Yeh.

	Per Cent.
Fe	60 to 62
P	0.05 to 0.25
S	0.05 to 0.12
SiO_2	3 to 5
Al_2O_3	1 to 2
Mn	0.2 to 0.4
Cu	0.05 to 0.25

At one place it is slightly magnetic, apparently having been partly reduced to the magnetic oxide by the action of reducing solutions, which have deposited small amounts of copper and iron sulphides along the foot-wall. During the Ming dynasty,

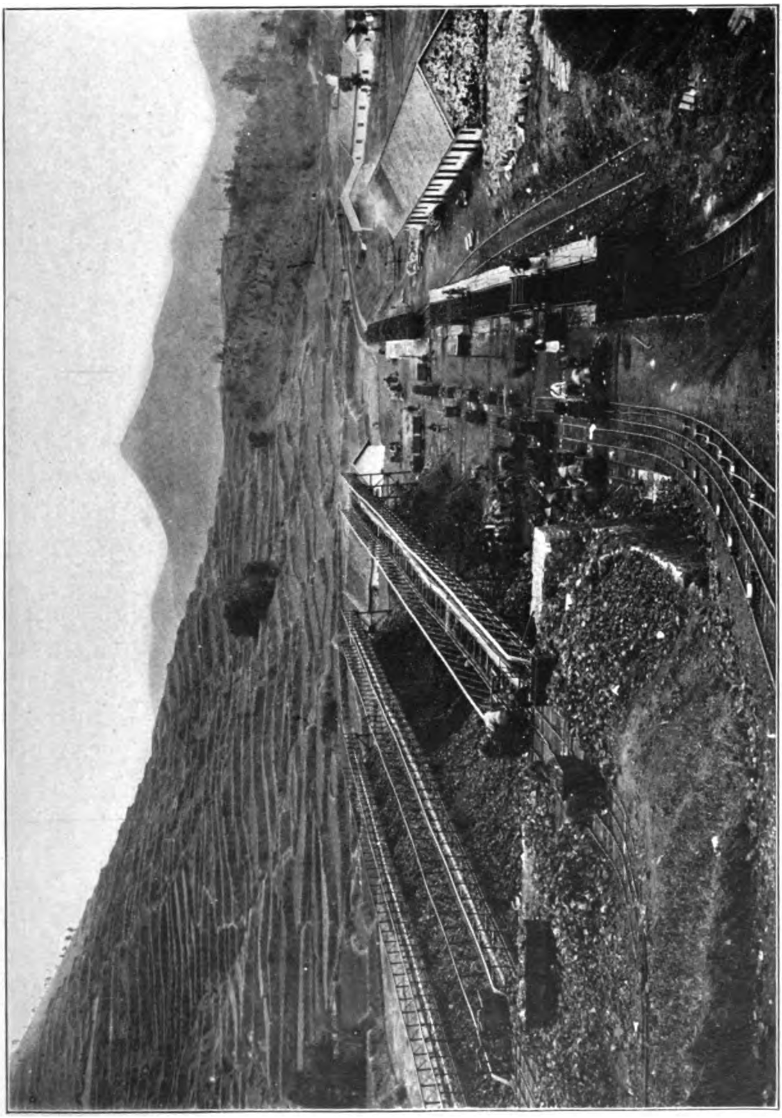


Fig. 15.—Loading-Plant at Ta-shih-men, Ta-yeh Iron-Mines.

FIG. 16.—STRIPPING THE OVER-BURDEN IN THE OPEN-CUTS AT TA-SHIH-MEN, TAYEH IRON-MINES. THE IRON-ORE IS HANDLED IN THE SAME WAY.

FIG. 17.—LOADING ORE IN CARS, TA-YEH IRON-MINES.

efforts were made to work this deposit as a copper-mine, but could scarcely have been very successful. The iron-ore is opened up over a length of more than 2 miles, but apparently is not continuous over that extent. The contact runs nearly east and west, and for considerable distances to each side of the present workings the ores can be traced. Where it is worked the ore-body is about 200 ft. thick and is nearly vertical, dipping slightly to the north. Fig. 15 is a view of the loading-plant at the Ta-Yeh mines, and Figs. 16 and 17 illus-

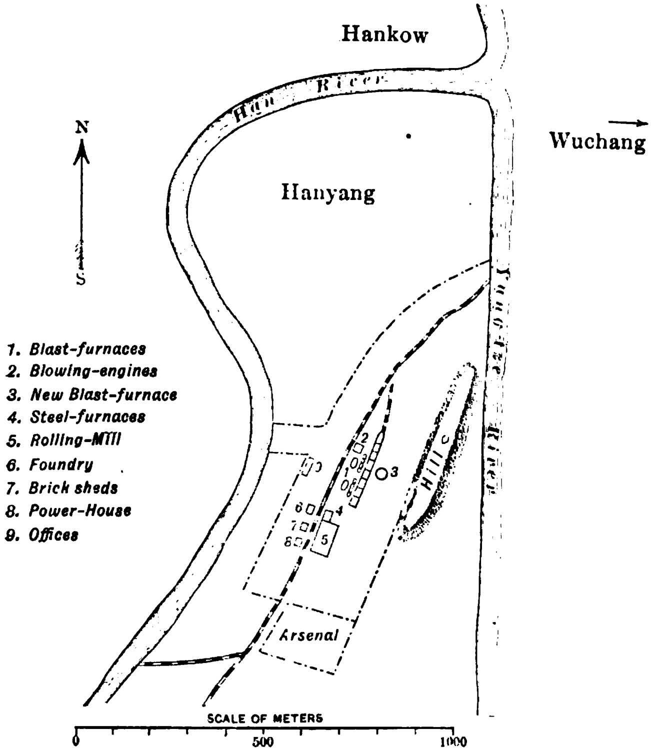


FIG. 18.—PLAN OF STEEL-WORKS, HANYANG.

trate the method of stripping the over-burden and loading the ore into cars. The syenite lies to the north of the marble, and a few miles farther north the marble again appears, iron-ore again being present along the contact. It would be entirely impossible to estimate the amount of ore available in this district, as in the workings only open-cuts are made, and the ore is nowhere blocked out in such a way that it can be accurately

measured; however, the officers of the mining company believe that they have many millions of tons of good ore on their property, and there seems no reason to doubt this.

At the metallurgical works at Hanyang, a plan of which is given in Fig. 18, two blast-furnaces, each of 100 tons daily capacity, are in operation, and a third unit of 250 tons capacity has just been completed. Three Siemens-Martin open-hearth furnaces are in operation, two are under construction, and five more are projected. The rolling-mill has a capacity of 800 tons per day; the larger part of it is devoted to rolling railway-material, as the greatest demand in China is for material of this nature. During 1909 there was produced 307,500 tons of iron-ore, of which a large part was exported to Japan and America, and the remainder smelted at Hanyang. Of the resulting pig-iron, 44,300 tons was sold as such, and the remainder converted into 28,500 tons of steel, chiefly steel rails; 3,600 tons of manganese-ore of good quality was produced in 1908 at P'ing-hsiang, in the province of Kiangsi. In several other places the company owns deposits of manganiferous limonite which contains about 20 per cent. of manganese, which can also be utilized if necessary. The company has a contract with the Japanese government iron-works at Wakamatsu to supply them with ore of Bessemer grade, and has recently made a contract with the Western Steel Corporation to furnish it yearly with 36,000 tons of ore and 36,000 tons of basic pig-iron.

The occurrence of iron-ore throughout the Empire is given in the following list of the places where deposits of iron-ore are known to exist, beginning at the north.

In Manchuria quite an amount of iron is produced [19] by native methods at T'ieh-ling, 44 miles north of Mukden, the ore coming from an adjacent range of hills. Recent Japanese reports are to the effect that iron-ores containing about 50 per cent. of iron exist along the line of the Mukden-Antung railroad, and also at Sai-ma-chi, Tung-hua, and 'Puaijin.' The NE. part of the province is only sparsely settled, and no other deposits have yet been opened.

Practically nothing is known of the iron-resources of the vast extent of Mongolia. At present the lack of transportation removes them from consideration, but it is not unlikely that

the Peking-Kalgan railroad will be extended to meet the Trans-Siberian road, and the coal- and iron-resources of this great area may have to be considered in the future.

The iron-ores of Shansi have already been described. Richthofen states that in Shensi the conditions as regards iron-ores are probably similar to those in Shansi, and assigns their lack of development to the character of the coal, which is not so suitable for the native methods of smelting. The fact that Shansi lies much nearer the markets for iron is also of importance, for where transportation is so expensive it would be impossible to ship across a producing district and compete with it, unless conditions were immensely more favorable in the more remote district. At any rate, Shensi must also be included as an area of which but little information is available at present, but which may become of importance in the future.

In the province of Chili iron-ore occurs at several places, notably in the NE. part; but I do not regard any of these as likely to become the basis of a permanent industry.

Magnetite occurs in the province of Shantung, at P'ao-shan, about 50 *li* south of T'ung-chou. Not far from this locality, at 'King-kwo-shan,' a different ore occurs, according to Williamson.[52] Near Chefoo specular ore occurs. It is not probable that the ores at these and numerous other places in the province offer much promise of success by development on a large scale, otherwise the German interests which have been so active in stimulating the growth of industry in the province would have undertaken their exploitation.

In Kiang-su province iron-ores are widely distributed, occurring chiefly in the region about Nanking in association with the limestone previously mentioned. Richthofen[45] seems to regard these of little promise because of the absence of coal of suitable quality in the neighborhood. But when the distance to which iron-ores are transported in the United States is considered, and the fact that the ores in question are conveniently adjacent to the Yangtze river, it seems much more probable that these ores will be the next to be developed on a modern scale. The ore is probably of similar character to that at Ta-yeh, previously described.

In the province of An-hwei the geological conditions are similar to those in Kiang-su and Hu-pei. A concession was

granted to the London & China Syndicate to exploit copper-mines in this province. A few years since, when the Chinese government was about to cancel the concession, the company claimed to have developed ore of a value of more than $4,000,000. But I have been unable to secure any accurate information regarding this concession.

The iron-ores of Hu-pei province have already been described. A recent report made by some students sent out by the provincial government is to the effect that workable deposits exist at six localities.

The province of Ho-nan is largely alluvial plain. In the NW. part the conditions are similar to those existing in Shansi, and similar ores occur. These ores have not been the basis of a flourishing native industry, but some large deposits are known to occur, and it has recently been proposed to develop them by modern methods.

In Ssu-ch'uan iron-ore is widely distributed, and both Baber [1] and Hosie [18] mention numerous places in which it is the basis of a native industry; but neither of these authors gives enough details upon which to base a judgment as to the future of the industry.

In regard to Yun-nan and Kuei-chou information is even more meager. Numerous travelers and explorers agree that iron-ores are widely distributed throughout Yun-nan, but there is an entire absence of definite information. A similar statement may be made in regard to Kuei-chou. The native industry in these provinces must be in a flourishing state, judging by the exports of native material.

On the maps prepared by La Mission Lyonnaise the following places are marked as productive of iron: Ssu-chuan (105° 50′ E., 32° 10′ N.), (105° 40′ E., 29° 45′ N.), (104° 40′ E., 29° 15′ N.), (104° 50′ E., 29° 05′ N.), (104° 30′ E., 28° 48′ N.), (102° 05′ E., 29° 40′ N.). Kweichou (103° 0′ E., 26° 10′ N.), (102° 50′ E., 26° 50′ N.), (103° 30′ E., 27° 15′ N.), (104° 0′ E., 25° 20′ N.), (104° 50′ E., 29° 0′ N.), (104° 50′ E., 29° 20′ N.), (106° 05′ E., 27° 0′ N.). Yunnan (99° 45′ E., 24° 20′ N.). Kwangtung (109° 20′ E., 24° 40′ N.), (111° 05′ E., 24° 25′ N.), (111° 05′ E., 23° 50′ N.), (112° 0′ E., 23° 45′ N.), (113° 30′ E., 23° 0′ N.). LeClere [25] says that iron-deposits are common in Yunnan, and are worked in places where the

supply of charcoal is abundant. He also refers to the iron industry in the northeastern part of Kweichou. Duclos [18] reports what is almost incredible, that the Chinese smelt iron-ores in blast-furnaces in Ssu-chuan.

Iron-ore of inferior quality occurs in Hunan, but is only worked by the natives at Chin-chou, near the southern border of the province, where the quality is much better. Very probably exploratory surveys would disclose valuable deposits at points not convenient for the application of native methods.

The manganese-ores at P'ing-hsiang, in the province of Kiang-si, have already been mentioned. Manganiferous limonites also occur along the Yang-tze, in the NW. part of the province, and it is not improbable that ores occur in other parts of the province, but are not worked by the natives.

In Che-kiang province there is a native industry in an area extending from near Ning-po down into the province of Fu-kien. But as the ores consist of grains of hematite which are washed by hand from the sands of the streams, this district may be dismissed as of no future importance.

At 'An-Khoe,' in Fu-kien province, about 60 or 70 miles from Amoy, there is a large deposit of magnetite, estimated to contain 10,000,000 tons of ore, according to a report given to me by consular officials. It is favorably situated for working, but unfortunately the report says nothing as to the amount of titanium present in the ore.

In Kuang-tung and Kuang-si provinces, iron-ore is produced in Hsin-hui-hsien, and is both produced and smelted at Hsin-hui-hsien and Yang-an-hsien; the annual production at the latter place amounting in value to $250,000 gold.

The cost per ton of production of iron-ore in the open-cut workings at Tayeh is approximately as follows:

	Mexican Currency.
Stripping,	$0.08
Mining,	0.18
Tramming,	0.03
Powder, steel, etc.,	0.015
Superintendence,	0.06
Loading cars, freight to Yang-tze, etc.,	0.30
Total,	$0.665

From these data the probable cost of the ore delivered at the blast-furnace would amount to a little more than $1, Mex., per

ton. The cost of limestone is about two-thirds of this; the cost of coke $15, Mex., and coal about $8, Mex. These low costs are largely due to the low cost of labor. Ordinary unskilled labor receives from 200 to 300 *cash* per day, or from $0.08 to $0.12 gold. Skilled labor receives from $5 to $25 gold per month, and the efficiency of this labor is remarkably high. As a result, pig-iron and steel can be produced at a very low cost; pig-iron from this plant is not only sold in Japan, but also in New York and San Francisco. But as there is a growing market for the present output in China, it is scarcely likely to become a serious competitor in other markets, at least for the present.

In conclusion, it may be said that, while our knowledge of the iron-resources of the Chinese Empire is still inadequate, yet the general features appear to be these: Iron-ores are widely distributed throughout the Empire, from north to south. In many places these have been the source of a more or less considerable native industry, which is steadily waning, because of the unsatisfactory quality of the product. Owing to the peculiar features of the native methods it is not to be supposed that modern industries will necessarily develop in the same localities; on the contrary, the one modern plant is utilizing ores not previously worked by the natives, and this will not improbably be the policy of its successors. In this development of the iron and steel industry it is most probable that the Yangtze valley will have a leading place, as there seems good reason to believe that iron-ores of satisfactory quality, and in sufficient quantity, occur along a considerable portion of its length, and it also possesses the great commercial advantage of easy and cheap transportation, and a situation in the commercial center of the Empire. The extremely low cost of labor permits a low cost of production, making tariff for the protection of the industry entirely unnecessary. The low price of silver in recent years has operated to benefit China in a twofold manner: both by stimulating export trade and by discouraging imports. The resultant increase of wealth will give increased ability to meet the initial large expenditures necessary to develop modern plants. A large and increasing market is assured by the Imperial regulation that all materials required in the construction of railroads and other public works shall

be purchased from the Chinese plants, so far as these are able to furnish them. As a result, it is to be expected that the iron and steel industry of China will have a large and healthy growth.

IV. Gold.

Gold in China has unusual interest at this time, since the proposal to place the coinage of the Empire upon a gold basis is now receiving more serious consideration. The fact that the gold-production is so small has always acted as a strong deterrent to the establishing of a gold coinage. Since China produces but little of either gold or silver, and must purchase them with exports of merchandise, the advantage of buying silver at its present low price is apparent. At present silver and copper are the media of exchange; the former passing at an approximation to its bullion value, while the copper *t'ung-tz'erh* and *cash* are subject to daily fluctuations of value. As each province now issues coins, which pass only at a discount, or perhaps not at all, in other provinces, the transaction of business is subjected to a wholly unnecessary burden. The central government, having acquired control of the railways, will doubtless next proceed to complete its present shadowy control of banking, and a gold standard may be introduced, as large amounts of foreign capital are now invested in China, and interest payments are at present subject to sudden and extensive changes in the rate of exchange.

The absence of records of mineral production renders it difficult to obtain any knowledge of the gold-production of the Empire. The best approximation can be made from the customs-records of gold exported, since the amount used annually in the arts is but small. The export for 1908 was approximately $6,500,000; that for 1907 was $3,200,000. The occurrence of gold in China has been noted by Baber,[1] Garnier,[15] Duclos,[13] LeClere,[25] Jack,[21] Verschoyle,[49] Hoover,[16] Hosie,[18], [19], and others,[9], [14], [20], [26], [27], [28], [29], [33], [34], [35], [36], [39], [43], [44], [50], [51], [52], [54], [57]; but the most notable descriptions are by Hoover,[16] Hosie,[19] and Purington.[36] The last has described at length the occurrences of alluvial gold in northern Manchuria, along the Amur, Sungari, Tumen, Urga, and Nonni rivers and their tributaries, and its recovery by primitive washing-methods.

Gold also occurs in southern Manchuria, both in alluvial deposits and in narrow veins, frequently of the gash type. The Bureau of Mines of Manchuria has compiled a list of 10 localities where gold is worked in Fengtien province, and 40 others where it is known to occur.

Bogdanovitch [2] has published an excellent study of the deposits of the Liao-tung peninsula, dividing them into four classes: (1) existing stream-beds; (2) Pleistocene high-level gravels; (3) ancient valley alluvials; (4) marine placers. The northern area is of much greater importance. It will perhaps be safe to estimate that Manchuria produces from 75 to 80 per cent. of an annual output of from $5,000,000 to $7,000,000 for the whole Empire.

The gold-deposits of Chili have been described by Hoover. [16] These are widely scattered, the most notable being veins at Chin-Chang-K'ou (119° 56′ E., 42° 20′ N.), and at Chuan-Shan-tze (119° 12′ E., 42° 26′ N.). In 1910 the former was producing at the rate of $150,000 per year, and the latter $15,000 annually. There are numerous placers throughout the province, and Hoover [16] estimated the total production for 1908 as $1,000,000. In Shantung similar conditions prevail, except that the deposits are not so abundant.

The best-known mine in China is that of Chou-Yuen, about 40 miles SW. of Chefoo, where a quartz vein from 40 to 90 ft. wide has been uncovered for more than a mile in length. Curle [9] reports that 200,000 tons of ore, worth $10 per ton, has been developed. The ore is about 40 per cent. free milling, and many years ago a chlorination-plant was in operation upon the tailings from the stamps. The mine has been closed for many years by government order; but there has been constant effort on the part of foreign companies to secure the concession, and recently the Governor of Shantung petitioned the Peking government to allow the Chinese owners to operate the mine, fearing lest it might otherwise be lost. The near-by mines at P'ing-tu are probably of considerable value. In spite of the government prohibition of mining a certain amount of work is carried on quietly, and Hoover [16] estimated the gold production of Shantung at $12,000 annually. With the few exceptions noted there seems little probability that deposits of sufficient size can be developed to justify the construction of modern

milling-plants, the cost of labor being so low that primitive methods give cheaper working-costs. The tailings from the chlorination-plant, mentioned above, were bought by the neighboring farmers, who carried the material home, and, in the dull agricultural season, ground it in native mills and panned it. The deposits near Wei-hai-wei have been described by Verschoyle,[49] but are of little importance. In northern Manchuria, which has not been adequately prospected, large-scale workings may perhaps be developed; but throughout the rest of the Empire progress is likely to take the form of increase and improvement of native mines, efficient and inexpensive pumps being the most-needed equipment of native mines. Hansen has recently reported that between Lanchow, on the western border of Kansu, and the border of Thibet, numerous placer-workings exist, carrying as much as 2 g. of gold per cubic yard. A modern gold-milling plant is in course of erection at this place. Quartz veins also occur, containing from 1.5 to 2 oz. of gold per ton; but as these statements are apparently based upon the reports of natives, they must be received with caution. A recent Russian report is to the effect that on the areas of the Tushetvohanovsky and Tzentzenhanovsky concerns, Mongolia, between January 14 and September 2 this year, the gold-production was 84.25 poods (1 pood of placer gold equals $9,000 approximately), as compared with 88 poods in the corresponding period of 1910.

Throughout the rest of the Empire quantities of gold are produced in many places, most of which are known to be of little importance. Ssu-chuan and Yunnan have been of much interest, since they are but little known. The upper waters of the Yang-tze are known as the Chin-sha, or 'golden sand,' but this does not necessarily indicate, as has been assumed, that especially rich alluvials exist along its course. Many travelers have mentioned the known or rumored existence of gold-deposits in these two provinces, LeClere, Duclos, Baber, Hosie, Garnier, Jack, and Johnston, to name but a few, but definite information is only meager. At Mo-Lo, in Ssu-chuan (102° 05′ E., 28° 15′ N.), important quartz-deposits have been worked since 1880 by a combination of foreign and native methods. Small quantities of alluvial gold are reported from a great number of places, but in nearly every case the name of the

district is given in such a way that identification is difficult or impossible. In giving the native names of little-known places, either the Chinese characters should be employed, or else the latitude and longitude should be given. In Yunnan the most notable mines are at Ta-lan-tung (101° 45′ E., 23° 30′ N.) at an elevation of 7,300 ft. (LeClere[25]). These quartz veins in Palæozoic rocks are worked by native methods, yielding some $60,000 per year. At Kin-Kiang, 60 miles from Ta-li-fu, rich conglomerate beds are worked by the natives. On the maps prepared by La Mission Lyonnaise the following places are marked as productive of gold: Ssu-chuan (99° 36′ E., 30° 55′ N.), (99° 45′ E., 30° 40′ N.), (99° 55′ E., 30° 20′ N.), (101° 50′ E., 32° 40′ N.), (101° 40′ E., 32° 0′ N.), (102° 15′ E., 31° 40′ N.), (102° 0′ E., 29° 0′ N.). Yunnan (98° 45′ E., 23° 45′ N.), (99° 50′ E., 23° 20′ N.). Numerous other localities are mentioned in the references given, and with the great recent increase of transportation-facilities in Yunnan it is not at all impossible that the gold-mining industry will greatly develop.

Gold is known to occur in Kansu, and there are quartz veins in the upper valley of the Han-ho, in Shensi. Along the lower reaches of the Han-ho, in Hupei, there is a small amount of gold-washing constantly carried on. The same is true of Fukien, where, in the Shao-wu district, 150 miles NW. of Foochow, valuable deposits are said to exist. In Anhwei mines were formerly worked, and deposits are known to exist in Hunan and Kuangsi, but they are not much worked. The mines in Kuangtung are said to be valuable; but in all these cases, it is probable that the deposits are limited in extent and of no great richness. It may be said, in conclusion, that with the exception of Manchuria and the SW. provinces of China (Yunnan, and Ssu-chuan), the gold-mining industry gives but little promise of growth. In the districts mentioned the introduction of modern pumping-machinery and the removal of the restrictions which the authorities and superstition have placed upon the industry are likely to lead to a considerable development.

V. Silver.

Silver is of great interest in China, since it is the chief medium of exchange. But the domestic production of silver

is small, and China is, accordingly, a heavy buyer of the metal. An interesting subject for speculation is found in the source of supply of this metal during the period when China maintained but little communication with the outside world. About the time of the beginning of the Christian era there was a great deal of traffic with the countries on the SW. border, where the mining and smelting of argentiferous galena seems to have been a considerable industry. The best-known silver-mines are those in the northern part of Chili province, near Jehol. At the time when Li Hung-Chang was viceroy, foreign engineers were employed in their exploitation. Woo,[55] who has described the native methods of mining and smelting these silver-lead ores, which occur as veins in quartz-porphyry associated with Palæozoic sediments, says that the lack of success of the foreign enterprise was due to the high cost of the coke used and to the unsuitable character of the milling-machinery employed. The general and probably correct impression is that these veins are too limited in extent and too irregular in character to allow of their being worked with a profit upon a larger scale than that employed by the natives. The production in 1903 was estimated,[55], [16], at from 80,000 to 100,000 oz. per year. In the mountains to the west of the line of the Peking-Hankow railroad numerous small occurrences are known, but the production is probably insignificant. References to the occurrence of silver-ores in nearly every province may be found, but do not seem to warrant much attention. Duclos [13] mentions numerous places in Yunnan where silver is produced, being usually associated with lead and zinc. The production at Pei-cha-po he estimated as 10,000 oz., and says that small amounts are produced at 'Koung-chan,' 'Fou-lay-tchang,' 'Siao-in-tchang,' 'Tchou-tsin-tchang,' 'Sin-pao-tong,' 'Ta-lang-tchang,' 'Tchen-pien-tchang,' 'Mo-lay-tchang,' and 'Sin-tchang,' in Yunnan. At 'Tsai-tsc-chang,' in Kweichou, silver is obtained from an argentiferous galena. At 'Mou-pin,' in Ssu-chuan, an argentiferous galena containing a little gold occurs; silver is also found toward the north of the province, at 'Pe-tsoa-pa' and 'Hou-koua-tou.'

On the maps prepared by La Mission Lyonnaise the following places are marked as productive of silver: Ssu-chuan (101° 45′ E., 32° 10′ N.). Kweichou (104° 20′ E., 25° 12′ N.),

(104° 35′ E., 25° 05′ N.), (104° 15′ E., 28° 10′ N.). Yunnan (98° 45′ E., 23° 45′ N.), (99° 50′ E., 23° 20′ N.), (101° 0′ E., 26° 30′ N.). Kwangsi (106° 55′ E., 23° 0′ N.), (107° 50′ E., 21° 30′ N.). Kwangtung (108° 20′ E., 21° 40′ N.), (109° 45′ E., 22° 20′ N.), (110° 50′ E., 25° 10′ N.), (111° 0′ E., 24° 50′ N.), (111° 05′ E., 22° 20′ N.), (112 15′ E., 22 50′ N.), (114° 05′ E., 23° 25′ N.), (114° 05′ E., 24° 15′ N.). A Chinese company is now mining silver at Kwei-Hsien, in Kwangsi. The Jun Wah Sut Yip Co. was organized a few years ago with native capital to develop silver- and other mines in Kwangsi, and is carrying on extensive exploration- and development-work. Several foreign companies have attempted the development of silver-mines in southern China, but without much success. It must be admitted that, on the whole, silver-mining in China is of no great importance.

VI. Copper.

Copper has always been an important metal in China, brass and bronze, used for objects of use and adornment and as media of exchange, having played a prominent part in the national life from the earliest times. But in the case of copper, tin, nickel, zinc, and lead, the discussion of the metals separately offers difficulties, since the ores are associated and are often smelted together, giving rise to natural alloys. By far the most important supply of these metals is derived from the southwest. Yunnan is the most important, but copper also occurs in the neighboring regions. Duclos [18] gives a long list of places where copper is produced in Yunnan, and describes in some detail the work at San-Kia-Chang (99° 35′ E., 24° 40′ N.), where he estimated a yearly production of 42 tons. LeClere [25] has summarized as follows:

"The total production obtained by reduction with charcoal was, in the 17th century, at least 6,000 tons, but has decreased to from 1,000 to 1,500 tons. The decrease is not due to the impoverishment of the deposits, but to the disappearance of the forests, the scarcity of fuel permitting only the exploitation of deposits of unusual richness at the places most favorably situated in respect to transportation. The copper minerals are various. Phillipsite, cantonite, and more rarely cupriferous pyrite, are found in veins in the Carboniferous schists, but are almost abandoned. Sheets of cuprite with barite, and of native copper, intercalated in porphyrite, are highly esteemed, but the lack of explosives often makes it impossible to work them. Sandstones impregnated with copper carbonate are often found in the Trias. The principal deposits are in Triassic limestones, the net-work of veins

have been converted into carbonates, with only a trace of pyrite. The principal mining centers are: (1) 'Toung-tchouan' (101° 0′ E., 26° 30′ N.), the mines in Ssu-chuan, near the Blue river are connected with these; (2) 'Oui-si,' near Li-Kiang (97° 15′ E., 27° 15′ N.); (3) the neighborhood of 'Ouei-ning' (102° 15′ E., 26° 45′ N.) in Kweichou produces zinc and lead principally, and is directly governed by the mining official of Yunnan-hsien. The works will not take ores of lower grade than will give a smelting mixture of from 20 to 30 per cent. of copper; the latter is more common. This richness is obtained by careful hand-sorting at the mines. The ores lower in grade than 15 per cent. are piled up and form large dumps. The old slag-dumps are common near the old smelting centers and contain about 3 per cent. of copper. These facts demonstrate that Yunnan has extremely large resources of copper minerals, especially in the parts not workable by native methods."

The present chief source of supply from Ssu-chuan, according to Fox, [58] is at Hwei-li-chon, though an important mine exists at Pai-shui-ho.

Copper occurs in many other parts of China. While in Kiangsi in 1908, the local officials told me of a large copper-mine at Chang-pai-ling in the west-central part, which had recently been extensively developed, but was not successful. Clark [4] has described the copper-ores at Lao-Pao-chi in Anhwei; this is probably the area which was subsequently granted as a concession to Lord Lister Kaye. Considerable work was done upon this concession by the English company, but without conspicuous success, and in 1910 the concession was surrendered. Clark [4] also describes the production of copper by native methods near Jehol (118° E., 40° N.), and I have seen unimportant native workings in many other places. C. H. Hansen, who has recently been engaged in the work of constructing a 50-ton copper-smelting plant under government auspices at Yaokai, 70 miles west of Lan-chow, on the western border of Kansu, says that there are numerous mines within a radius of 80 miles from that point.

The mining of copper has always been rigorously under the control of the government, probably because of the importance of the metal as a medium of exchange. The native supply has not been equal to the demand recently, and considerable amounts are imported, chiefly from Japan.

VII. Nickel.

Nickel is of much technical interest because of the ingenious way the Chinese have of smelting mixtures of nickeliferous

copper-ores with tin, lead, and zinc-ores, forming the alloy "pai-t'ung," or "pakfong," as it is called in southern China. This is a kind of German silver, which is extensively used in the manufacture of candlesticks and other household objects. Nickel is never produced separately, and the entire supply is apparently drawn from southwestern China, where in Yunnan (at 100° 20′ E., 26° 50′ N.), and in Ssu-chuan (100° 20′ E., 26° 45′ N.), Duclos [18] has noted the occurrence of nickeliferous copper-ores.

VIII. Tin.

China is an important producer of tin, furnishing at present about 5 per cent. of the total production of the world. A certain amount of the product comes in native boats down the Yuen and Hsiang rivers, probably originating at some point in Kweichou. Kwangtung also produces a notable amount, which is exported through Wuchow. On the maps prepared by La Mission Lyonnaise the following places in Kwangsi and Kwangtung are marked as productive of tin: (105° 10′ E., 24° 12′ N.), (110° 15′ E., 24° 45′ N.), (110° 45′ E., 32° 15′ N.), (112° 0′ E., 23° 30′ N,), (112° 45′ E., 22° 50′ N.), (114° 10′ E., 23° 40′ N.). There are also deposits in Fukien, and a small amount is shipped from Foochow. But by far the larger part of the production comes from the well-known mines at Ko-ch'iu-ch'iang (100° 50′ E., 23° 20′ N.), in Meng-tze-hsien, Yunnan. Here the deposits, which LeClere [25] says "ne sont nullement alluvionnels: leur origéne filonienne est des plus evidentes," are scattered over an area 25 miles long and 20 miles broad, and 30,000 workers are engaged in mining and smelting the product of 150 mines. The workings are both surface and underground and only native methods are employed. Collins, [6] Duclos, [18] and LeClere, [25] have described these deposits in detail. Theoretically the deposits belong to the central government, which, according to the mining-regulations, exacts a royalty of 25 per cent., but the amount actually paid is somewhere between 12.5 and 18 per cent. The reports as to the production of these mines do not agree, but the customs return for 1909 was 4,700 tons, corresponding to about 90 per cent. of the total production for the Empire. The crude tin, in slabs, each weighing 74 lb., is exported to Hongkong, where it is refined. A large part of the tin was formerly

shipped down the Yang-tze and West rivers, but now it is shipped over the French railroad. Recent newspaper reports are to the effect that efficient smelting- and mining-machinery is to be installed, about $1,200,000 having been subscribed for the purpose, and the erection of a slag-cleaning plant has been proposed. It is not unlikely, therefore, that the production of tin in China will considerably increase in the near future.

IX. Lead.

There is a considerable demand for lead in China, which is largely met by imports, 10,707 metric tons of pig-lead having been imported in 1908. The domestic production is not inconsiderable, lead-ores occurring in 8 of the 18 provinces; Kweichou, Ssu-chuan, and Yunnan are the most important; but about 1,500 tons of ore were derived from Hengchou and Yangchou prefectures, in Hunan province, in 1908. The larger part of this is exported to Great Britain and Belgium, but considerable quantities are smelted at the works of Carlowitz & Co. at Wu-chang. About 350 tons of pig-lead was brought down the Yangtze through I-chang in 1907, and 300 tons in 1909. A good deal of lead-ore comes down the Yuen and Hsiang rivers, both from Hunan and Kweichou. Duclos [18] has described the production of lead at 'Tcha-tze-tchang' (102° 50′ E., 26° 45′ N.), in Kweichou, and notes its occurrence at (102° 40′ E., 26° 30′ N.). In Yunnan the mines contain mixed ores of lead, zinc, copper, and silver. In the neighborhood of 101° 0′ E., 26° 30′ N., at 'Kong-Chan-tchang' 1,450,000 lb. of lead is produced, at 'Pe-cha-po', 700,000 lb. of lead, at 'Koung-chau' the lead produced is cupelled for silver. Near 102° 20′ E., 26° 45′ N. there is a considerable production, both of lead and zinc. In many places argentiferous lead-ores are worked (see "Silver"), the bullion being cupelled; the resulting litharge often being thrown away. LeClere [25] estimated the annual production in southwestern China at around 3,000 tons. The lead-ores of Kwantung and Kwangsi are mentioned under "Silver." On the maps prepared by La Mission Lyonnaise the following points in Kwangtung are marked as productive of lead: (109° 50′ E., 21° 58′ N.), (110° 15′ E., 23° 57′ N.), (114° 05′ E., 23° 58′ N.). The native methods of metallurgy are so imperfect that it is not improbable that in many cases

deposits exist which could be worked by modern methods. But, as mentioned under "Silver," it has not infrequently been found that the veins are too narrow and irregular to yield a profit when exploited on a large scale.

X. Zinc.

The whole domestic supply of zinc in China is derived from the SW. provinces, chiefly Kweichou. Duclos[18] has described the native metallurgical method followed at 'Ma-lou-kio' (102° 50′ E., 26° 45′ N.), and mentions the occurrence of zinc in Yunnan at (102° 20′ E., 26° 45′ N.) and (101° 40′ E., 25° 30′ N.). LeClere[25] says that the workings are only superficial, and that the distillation-methods are so imperfect that much ore which could be utilized by modern methods has been discarded. He estimated the annual production at about 2,500 tons. The spelter from Kweichou, which I have seen, was obviously impure, but it is used in the provincial mints in making brass coins, without any attempt at refining. Large quantities of zinc-ore are produced in Hêng-chou and Yang-chou prefectures, Hunan, and exported to Belgium and Holland. The export for 1908 was more than 15,000 tons, but for 1909 was very small.

XI. Antimony.

China possesses the distinction of being first in the production of this metal. The condition of the industry has been changing rapidly of recent years. My notes were made on a visit to the chief center of production in 1908. The ore comes from a number of places to NW of T'ung-t'ing lake in Hunan, I-yang being the chief center (110° E., 29° N., approximately). It is carefully hand-sorted at the mines, and is brought in native boats to Changsha (112° '45′ E., 28° 15′ N.), where it is liquated in pots about 15 in. in diameter. The methods were entirely Chinese at that time, but I understand that furnaces of modern construction have since been installed. The regulus is sent to Hankow, and so much as desired is converted into metal. The residues have been exported to France, Germany, and the Netherlands for further treatment; more recently large quantities have been sent to the United States. Carlowitz & Co., who operate a smelter at Hankow, are also engaged in the work of smelting and refining both antimony

and lead, but as strict secrecy is observed, details are not obtainable. The production for 1907 from this district in Hunan, according to customs returns, was 3,957 tons of regulus and 14,810 tons of ore. In 1908 the production of regulus increased to more than 8,000 tons, and the ore-shipments decreased to less than 2,000 tons. The native company which operates the smelter has trained metallurgists in its employ, and the industry is likely to further increase in importance.

Antimony also occurs in Kiangsi, Kweichou, and Ssu-chuan, but Kwangtung is the next most important province after Hunan. Recently a smelter under government auspices was established at Wuchou (111° 30′ E., 23° 30′ N.), but was not a success, and has since been closed. A more extended discussion can be found in the *Mineral Industry* for 1908 and 1909, and in the volume *Antimony*, by C. Y. Wang (London, 1909).

XII. Quicksilver.

Quicksilver has a steady demand in China, most of the metal being used in the production of vermilion, which enjoys high favor as a pigment, a less important use being in gilding by the Chinese method. The native production fluctuates greatly, the amount reported by the customs authorities being 30 tons in 1907, and 65 tons in 1908. It is impossible to determine what relation exists between the total amount produced and that reported by the customs. Most of the demand is supplied by imports, largely from California. The occurrence of quicksilver is reported from many parts of the Empire, but the deposits in the province of Kuei-chou are, apparently, the only ones of commercial importance. As I have not visited these districts, my information is entirely derived from published statements. Duclos [18] has noted several places in Kweichou where quicksilver is produced; 'Oa-tchouan' (105° 50′ E., 28° 30′ N.), Pei-ma-t'ong (104° 15′ E., 26° 48′ N.), Lan-mou-chang (103° 15′ E., 25° 28′ N.), and Yang-li (104° 20′ E., 15° 0′ N.) are the most important. He estimated the production at Pei-ma-t'ong as 6,500 lb. per year, and says that at Yang-li there is "*une enorme exploitation.*" He also mentions the occurrence of quicksilver in Yunnan (101° 10′ E., 23° 30′ N.). LeClere [25] was not favorably impressed by the mercury-deposits, and remarks, accurately enough, that the native methods of work can

treat ore of quite as low grade as would be profitable by foreign methods. Brelich[3] says that the deposits at Wan Shan Chang, in Toon Yen préfecture, are the largest and most extensively worked in Kuei-chou. They occur in nearly horizontal beds of magnesian limestone: (1) impregnating well-defined beds; (2) along joints and planes of stratification; (3) in isolated bunches and vugs; (4) irregularly disseminated. The ore is hand-sorted and retorted in native furnaces. Brelich says the miners work for daily wage, which is unusual. The Anglo-French Quicksilver & Mining Co. began work at Kwei-yang in 1899, with a capital of £310,000, operating the Wen Shan Chiang mines, which are 12 miles north of the Yuen river. These are apparently the mines which Brelich describes. The area of the concession was 4 sq. miles. Two 12-ton Granitza furnaces were constructed, and the production from 1899 to the end of 1902 was 32,500 lb. of quicksilver and 500 lb. of cinnabar. The company has had a somewhat checkered career, and little progress is now being made.

XIII. Arsenic.

Arsenic is of no little importance in China, but detailed and accurate information regarding its occurrence and production is not obtainable. According to the customs returns, 5,000 tons was produced in 1908, but only 400 tons in 1909. Apparently the ore occurs in or near the principal antimony district (111° E., 29° N.), since the product passes through the same custom-house. About 700 tons of arsenic-ore from China was imported into Germany in 1908. A recent French report estimates the annual production of orpiment and realgar in Yunnan at 600 tons. This comes from near Chao-chou and Meng-hua, in Tali prefecture.

XIV. Petroleum.

The most notable petroleum-producing district is in Ssu-chuan, where, according to Coldre,[5] there are in the neighborhood of Yun-hsien (102° 10′ E., 29° 38′ N.) and Fu-chuan (102° 43′ E., 29° 27′ N.) from 30 to 40 wells, from 1,000 to 3,500 ft. deep, in which petroleum occurs associated with gas and brine. The gas is employed in evaporating the brine, and the petroleum, which varies from '*blanc de petit lait*' to '*noir*,' is burned in crude lamps without any attempt at refining.

Duclos[18] describes the wells at 'Tse-liou-tsin,' which is between Yun-hsien and Fu-chuan, nearer the latter, giving the number as about 150; but probably this refers to the total number rather than those which actually produce petroleum. But neither gives any estimate of the amount of actual production. Richard[48] refers to the occurrence of petroleum in Kansu, but does not give the locality. Recent press reports are to the effect that petroleum has been found near the Kanchou coal-mine, in Kansu, but no definite information is available.

A field that is of present importance occurs near Yen-chang (110° 0′ E., 36° 30′ N.), in Shensi. A native company has been at work there for some years, has recently constructed a refinery, and is now selling oil throughout Shensi in active competition with the foreign product. I have been unable to obtain reliable detailed information regarding this field, but it is probably of a great deal of importance, since it is rumored that the company is considering the construction of a light railway from the wells to Singan-fu, 200 miles distant. Apparently petroleum occurs only in the western and SW. parts of the Empire, but in these places a considerable native industry is likely to develop when the areas are provided with adequate transportation-facilities.

In concluding this paper, it should be added that the development of the mineral resources of the Chinese Empire would be greatly aided by the creation of an Imperial Geological Survey. The nucleus of such an organization already exists in the many Chinese geologists and engineers who have been trained abroad, and with proper organization and sufficient funds, this important and necessary work would redound to the immense benefit of the mineral industry.

XV. Bibliography.

[1] Baber, E. Colborne: Travels and Researches in Western China, *Royal Geographical Society Supplementary Papers*, Vol. I, Pt. I.

[2] Bogdanovitch: Materialen zur Geologie Russlands, *Zeitschrift für praktische Geologie*, Vol. VII, p. 240 (1899).

[3] Brelich: Chinese Methods of Mining Quicksilver, *Transactions of the Institution of Mining and Metallurgy*, Vol. XIV, p. 483 (1904–05).

[4] Clark, Ellis: Notes on the Progress of Mining in China, *Trans.*, XIX, 571 (1890–91).

[5] Coldre, Louis: Les Salines et les Puits de Feu de la province du Se-Tchoan, *Annales des Mines*, Ser. 8, Vol. XIX, p. 441 (1891).

[6] COLLINS, W. F.: Tin Production in the Province of Yunnan, China, *Transactions of the Institution of Mining and Metallurgy*, Vol. XIX, p. 187 (1909–10).
[7] COLLINS, W. F.: *Mineral Industry*, Vol. XVIII, p. 672 (1909).
[8] CORDIER, HENRI: *Bibliotheca Sinica* (1904).
[9] CURLE, J. H.: *Gold-Mines of the World* (1899).
[10] DRAKE, N. F.: The Coal-Fields around Tsê-Chou, Shansi, China, *Trans.*, XXX, 261 (1900).
[12] DRAKE, N. F.: The Coal-Fields of Northeastern China, *Trans.*, XXXI, 492 (1901).
[13] DUCLOS: *La Mission Lyonnaise d'exploration commerciale en Chine*, 1895–7. Pp. 283 to 314 (Lyons, 1898).
[14] GARRISON, F. LYNWOOD: *Mining and Metallurgy*, Feb. 15, 1901, p. 106.
[15] GARNIER: *Voyage d'exploration en Indo-Chine*, Vol. I, p. 230 (1867).
[16] HOOVER, H. C.: Metal Mining in the Provinces of Chi-li and Shantung, China, *Transactions of the Institution of Mining and Metallurgy*, Vol. VIII, p. 324 (1899–1900).
[17] HOOVER, H. C.: Kaiping Coal Mines and Coal Field, Chihle Province, North China, *Transactions of the Institution of Mining and Metallurgy*, Vol. X, p. 419 (1901–02).
[18] HOSIE, ALEXANDER: *Three Years in Western China.*
[19] HOSIE, ALEXANDER: *Manchuria, Its People, Resources and Recent History.*
[20] HUC, E. R.: *Travels in Tartary, Tibet, and China.*
[20a] INOUYE, K.: *Geology of the Southern Part of Shêng-ching Province* (Tokyo, 1905).
[21] JACK: *Back Blocks of China.*
[22] JOHNSTON: *From Peking to Mandalay.*
[23] JAMESON, C. D.: Coal and Iron in Eastern China, *Engineering and Mining Journal*, Vol. LXVI, p. 365 (1898).
[24] KWANG, K. Y.: The Kaiping Coal-Mine, North China, *Trans.*, XVI, 95 (1887–88).
[25] LECLÈRE, M. A.: Étude Géologique et Minière des Provinces Chinoises voisines du Tonkin. Paris, 1902. *Annales des Mines*, Ser. 9, Vol. XX, p. 287 (1901).
[26] LE PRINCE-RINGUET: Étude Gèologique sur le nord de la Chine, *Annales des Mines*, Ser. 9, Vol. XIX, p. 393 (1901).
[27] LORENZ, TH.: Beitrage zur Geologie von Ostasien, *Deutsche Geologische Gesellschaft*, Vol. LVII, p. 475 (1905).
[28] MACLAREN, MALCOLM: *Gold*, p. 270 *et seq.* (1908).
[29] MARGARY, A. R.: *Journey from Shanghai to Bhamo* (1876).
[30] MOLLER, W. A.: The Fushun Colliery, South Manchuria, *Trans.*, XLI, 241 (1911).
[31] MONOD, G. H.: Coal Fields of Indo-China, *Revue Métallurgique* (Sept. 19, 1904).
[32] MURDOCH, J. V. B.: Brine and Oil Wells in Western China, *Transactions of the Institution of Mining and Metallurgy*, Vol. IX, p. 362 (1900–01).
[33] PERVINQUIÉRE: *Revue Scientifique*, Ser. 5, Vol. I, p. 547 (1904).
[34] PREJEVALSKI: *Travels in Mongolia.*
[35] PUMPELLY, RAPHAEL: Geological Researches in China, *Smithsonian Contributions*, Vol. XV, p. 118.
[36] PURINGTON, C. W.: Northern Manchuria, *Mining Magazine*, Vol. IV, p. 53 (1911).
[37] READ, T. T.: Coal Mining in China, *Mining and Scientific Press*, Vol. XCVIII, p. 44 (1909).

[38] READ, T. T.: Coal Mining in Manchuria, *Mining Magazine*, Vol. I, p. 215 (1909).

[39] READ, T. T.: Mineral Resources of Manchuria, *Mining Magazine*, Vol. II, p. 121 (1910).

[40] READ, T. T.: Steel Making in China, *Mining Magazine*, Vol. II, p. 199 (1910).

[41] READ, T. T.: Iron Ore Resources of the Chinese Empire, in *The Iron Ore Resources of the World*, pp. 915 to 924 (Stockholm, 1910).

[42] The Lanchow Mining Co., Ltd. *Far Eastern Review*, Vol. VIII, p. 41 (July, 1911).

[43] RICHARD, L.: *Comprehensive Geography of the Chinese Empire* (Shanghai, 1908).

[44] RICHTHOFEN, F. F. VON: *China, Ergebnisse eigener Reisen und darauf gegründeter Studien* (1877).

[45] RICHTHOFEN, F. F. VON: Letters to the Shanghai Chamber of Commerce, 1872 (Shanghai, 1903).

[46] ROCHER: *La Province Chinoise du Yunnan* (1879).

[47] SHOCKLEY, W. H.: Notes on the Coal- and Iron-Fields of Southeastern Shansi, *Trans.*, XXXIV., 841 (1904).

[48] SWENSEN, K. P.: The Pinghsiang Colliery, *Mining and Scientific Press*, Vol. CI, p. 564 (1910).

[49] VERSCHOYLE, W. D.: Gold Mining at Wei-hai-Wei, China, *Engineering and Mining Journal*, Vol. LXXXII, p. 919 (Nov. 17, 1906).

[50] VOGELSANG: *Petermanns Mittheilungen*, Vol. XLVII, p. 245 (1901).

[51] VON CHOLNOKI: *Földtani Közloni*, Vol. XXIX, p. 289 (1900).

[52] WILLIAMSON, ALEXANDER: *Journeys in North China, Manchuria, and Eastern Mongolia*, 1870.

[53] WILLIS, BLACKWELDER, and SARGENT: *Research in China*, 1907. (Published by the Carnegie Institution.)

[54] WILLIS, BAILEY: The Mineral Resources of China, *Economic Geology*, Vol. III, pp. 1 and 118 (1908).

[55] WOO, Y. T.: Silver-Mining and Smelting in Mongolia, *Trans.*, XXXIII, 755 (1903).

[56] WOO, Y. T.: The Manufacture of Coke in Northern China, *Trans.*, XXXVI, 661 (1906).

[57] YULE, SIR HENRY: *The Book of Ser Marco Polo, the Venetian* (1875).

[58] FOX, H. H.: Memorandum on Chinese Mines, *Diplomatic and Consular Reports*, No. 680 (London, 1911).

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Proceedings of the One Hundred and Second Meeting, New York, N. Y., February, 1912.

COMMITTEES.

Reception, Monday, Feb. 19.—Benjamin B. Lawrence, *Chairman*.

W. A. Bostwick, W. DeL. Benedict, J. Parke Channing, W. B. Kunhardt, A. R. Ledoux, Edwin Ludlow, Charles F. McKenna, Ambrose Monell, H. S. Munroe, C. P. Perin, Pope Yeatman, Charles Rand, D. M. Riordan, P. de P. Ricketts, Thomas Robins, E. G. Spilsbury,

Reception, Tuesday, Feb. 20.—Arthur S. Dwight, *Chairman*.

Lawrence Addicks, J. H. Banks, William Campbell, A. C. Carson, B. E. Eldred, H. W. Hardinge, L. D. Huntoon, J. H. Janeway, Jr., W. McA. Johnson, C. H. Jouet, E. L. Kurtz, J. F. McClelland, R. G. Moldenke, W. H. Nichols, Jr., H. A. J. Wilkens. Charles Of, H. A. Prosser, E. Randolph, G. C. Stone, F. W. C. Schniewind, Leonard Waldo, A. L. Walker,

Reception, Wednesday, Feb. 21.—John D. Irving, *Chairman*.

A. Chester Beatty, A. A. Blow, William Braden, J. Morgan Clements, R. A. Cook, E. L. Dufourcq, Theodore Dwight, L. W. Francis, E. O. Hovey, Sidney J. Jennings, Joseph W. Roe, W. L. Saunders, J. M. Sherrerd, F. M. Simonds. H. Souther, E. S. Sperry, J. R. Stanton, Knox Taylor, H. S. Washington, J. E. Woodman,

Dinner, Feb. 20.—James Gayley, *Chairman*.

Albert R. Ledoux, D. M. Riordan, Theodore Dwight, Thomas Robins.

Finance.—George D. Barron, *Chairman*; Theodore Dwight.

The 102d meeting of the Institute was held at the Institute headquarters in the Engineering Societies Building, New York, N. Y., on Feb. 19, 20 and 21, 1912. A Bureau of Information, in charge of Mr. George Buckman, was maintained during the meeting.

The proceedings opened with an informal social meeting on Monday evening, Feb. 19, in Assembly-Room No. 1, on the

fifth floor of the building. The meeting was in charge of the New York Section of the Institute, and Mr. Benjamin B. Lawrence, Chairman of the Reception Committee for the day, delivered the address of welcome, after which Mr. Charles Kirchhoff, President of the Institute, addressed the gathering on Institute Aims and Ideals, as follows:

During the past few years there have been far-reaching and notable developments in the work of many of the national and local technical societies. The Carnegie gift has stimulated enthusiasm, and has fostered co-operation among engineers through the completion of the Engineering Building on the professional side, and through the enlargement of the Engineers' Club on the social side. While the splendid results thus obtained have been most noticeable locally, their influence is penetrating slowly throughout the country, and combined efforts are being made to make them available in an increased measure to all. In these aims the Institute is actively participating.

I have observed that with wider opportunities and enlarged facilities, the ambitions of the national engineering societies have grown. They are beginning to go beyond the collection and distribution of technical data; they are seeking to directly promote progress through research committees, backed, if necessary, by adequate appropriations. Some magnificent work has been done in this direction abroad, a striking example being the study of the power-requirements of rolling-mills, by a commission of the Verein deutscher Eisenhuettenleute, under the direction of Dr. Puppe.

There are elements in every national engineering society which affect to a varying degree the attainment of its principal objects, which are the accumulation of facts and thoughts, the exchange and discussion of experience and practice; the fostering of acquaintance and friendship, and the promotion of the solidarity of the profession. These elements are the tendency towards specialization, and the scattering of the membership geographically. So far as both tendencies are concerned, the Institute is affected perhaps more than any other society. Specialization in mining and metallurgy, and the cognate sciences, has gone very far since the days of the organization of the Institute, and has had its deep effect upon it. That part of our membership which is directly connected with operating mines, mills, and works, is very much scattered in the nature of things.

To a greater or less extent, the principal technical societies have endeavored to meet these conditions in two ways, by the organization of Local Sections, and by the establishment of professional divisions. Particularly in the mining and metallurgical industries, local sections bring together members who have identical or closely allied professional interests, and a keen appreciation of the opportunities and advantages of social intercourse. This is true notably where the distractions of a large city are missing. During the past year a movement in the direction of the organization of local sections has been initiated, and while it has had a measure of success, there are often special conditions which must be worked out. The experience of other societies who have gone further in this direction would indicate that such organizations often need financial support, which in the aggregate involves considerable demands upon the resources of the parent body. But they should prove a powerful factor for mutual advantage. They offer to the active member of a local section the opportunity to obtain for his professional work an international audience where his paper has been accepted for publication in

the Transactions of the Society, which local engineering bodies cannot offer. They stimulate the presentation of information on practice in one field which is valuable to those in other sections and in other branches, and give the younger men opportunities for training in collecting and presenting facts and meeting comment and discussion.

The feeling that the tendency towards specialization must be reflected in some modification in the organization of the societies has existed for a long time, and has in one conspicuous instance led to the formation of a relatively large series of topical divisions.

Meetings at which a series of papers covering many parts of the field are brought up in succession can rarely be of sustained interest to more than a few of those in attendance. If the number of those present qualified to discuss or supplement a paper on a special subject is small, the author feels himself chilled by an indifferent or unsympathetic audience. In the Institute effort has been repeatedly made—taking advantage of the fact that the meeting was being held in a locality where particular industries predominated—to bring out papers connected with those industries, and induce attendance of members identified with them. Such efforts have been crowned with a measure of success, but they could not then be persistently followed up. I believe the time has come when they should be systematized by providing the facilities for the organization of topical sections. The mission of these would be the intense cultivation of their respective fields, in the place of the casual representation of different branches of the whole range of mining and metallurgy, to which the present methods cannot help being restricted. There must be a concentration of effort which shall bring to the members interested in each division the conviction that the Institute is not alone keeping abreast of progress in that field, but is leading it.

In an able address, delivered at the annual meeting in 1889, by the President of the Institute, Prof. W. B. Potter, he suggested for a grouping the following: I. Iron and Steel; II. The Precious and Base Metals; III. Geology and Mining; IV. Chemistry. Probably we might to-day be inclined to split the third group into Economic Geology and Metal- and Coal-Mining, but it is much more strikingly true to-day than it was in 1889 that we must adjust the organization of the Institute to the changes in the relations of the individual members to the work which it is to perform. The Institute has a splendid mission before it in this direction, but if it does not rise to that mission, the inevitable result will be that a series of societies will be formed which will aim to carry out the work. From the standpoint of efficiency such an outcome should be deeply deplored. The advantages of one powerful organization in charge of interests which after all are interlocked at so many points, with the prestige and success of forty years of splendid achievements, should not be lightly surrendered to a series of bodies, each singly weak

While doing more intense work in special fields, the Institute has missions in other directions which would be common to all interests, and would tie them together. Besides, its central organization could more effectively and cheaply carry on the purely administrative functions, and the editorial and publication work.

While the Institute could depend upon the voluntary efforts of many members now leaders in the different groups or sections, it would probably soon develop that the services of special officers, fairly compensated, would be required. The volume of the publications would be greatly enlarged, but the accessions to the membership at large, or to affiliates of special groups, would meet all additional outlays after a probable period of development. One leading society has gone so far as to print three separate sets of publications.

Another field of endeavor should be given close consideration, which the

founders of the Institute put forward with striking emphasis. Let me quote from the first circular sent out by Eckley B. Coxe, R. P. Rothwell, and Martin Coryell, dated Wilkes-Barre, April, 1871, which led to the organization of the Institute at the meeting of May 16, 1871:

"The great development of the mines and metallurgical work of this country during the last few years, accompanied as it has been by the investment of enormous sums of money in purchasing lands and in the erection of improvements, requires that advantage should be taken of the accumulated knowledge of engineers, superintendents and others in mastering the problems which are constantly presenting themselves for our action. Among those may be mentioned, the consideration of more economical systems of mining in our coal and metalliferous mines—improved methods of transportation above and below ground; unwatering and ventilating mines; the mechanical preparation of coal and other minerals; the various metallurgical processes, and in fact, every question tending to the attainment of the two great objects:

"1st. The more economical production of the useful minerals and metals.

"2d. The greater safety and welfare of those employed in these industries."

It will be observed that the signers of the first invitation laid particular stress upon the duty to safeguard the men employed in the mining and metallurgical industries; a mission of the Institute which has not received the attention which it deserved It has, however, engaged public interest keenly in recent years, and splendid progress has been made by governmental and private agencies. These should have the active co-operation of the Institute, notably in the direction of discussing the many questions of a strictly technical nature, with which the members are so eminently qualified to deal.

This leads to the question, to what extent the Institute may and should participate in the discussion of public questions generally. Our Constitution provides that special committees may be appointed to make investigations and reports for presentation to the Institute, but specifically forbids that any action shall be taken binding the Institute for or against the conclusions embodied in any such reports. While that prohibition is beyond a doubt a very wise one, and avoids serious dangers, it would seem that a powerful influence for good may be exerted by committees' reports, and by the discussions to which they might lead.

The past achievements of the Institute justify the expectation that the highest estimate of its mission may be attained if the membership will co-operate heartily in its work. It is only by general participation in its enlarged activities that there can be realized the splendid possibilities for good to the profession, to the industries which it represents, and to the individual members themselves.

Prof. James F. Kemp related some humorous experiences in mountain-climbing as a prelude to his illustrated discourse on The Formation of Mineral Veins, which terminated the program. The members then adjourned to the Institute rooms on the ninth floor of the building for further social intercourse.

The Annual Business Meeting of the Institute was held on Tuesday morning, February 20, 1912. An account of the business transacted is given on p. xvii of the *Bulletin*.

The technical sessions were held in Assembly-Room No. 1, on the fifth floor of the Engineering Societies Building. Mr.

Charles Kirchhoff presided at all of the sessions. The first session, Tuesday, Feb. 20, at 2 p.m., was allotted to papers on the sintering and briquetting of fine ores, flue-dust, etc. The following papers were presented in oral abstract by the authors, with the exceptions noted:

*The Sintering of Fine Iron-Ore, by B. G. Klugh, Birdsboro, Pa. (Read by George W. Maynard. Illustrated by samples of sintered material. Discussed by J. L. W. Birkinbine, Alfred H. Cowles, H. M. Chance, Arthur S. Dwight, Anton Eilers, Henry M. Howe, N. S. Keith, Charles Kirchhoff, George W. Maynard, Joseph W. Richards, F. W. C. Schniewind, E. Gybbon Spilsbury, J. W. Tudor, and F. A. Vogel.)

*Agglomeration of Fine Materials, by W. S. Landis, South Bethlehem, Pa. (Read by Joseph W. Richards.)

*Sintering and Briquetting of Flue-Dust, by Felix A. Vogel, New York, N. Y. (Mr. Vogel displayed a collection of briquettes and nodulized materials. The paper was discussed by Arthur S. Dwight, F. W. C. Schniewind, Otto Sussmann, Felix A. Vogel, and Arthur L. Walker.)

*The Schumacher Briquetting Process, by Joseph W. Richards, South Bethlehem, Pa. (Discussed by Alfred H. Cowles, Arthur S. Dwight, Henry M. Howe, Joseph W. Richards, and F. W. C. Schniewind.

The Grondal Briquetting Process, by N. V. Hansell, New York, N. Y. (Discussed by Alfred H. Cowles, N. V. Hansell, and George W. Maynard.)

*Electrostatic Concentration or Separation of Ores, by H. A. Wentworth, Boston, Mass. (Discussed by Robert H. Richards.)

The second session was held on Wednesday, Feb. 21, at 10 a. m.

The following papers were presented in oral abstract by the authors:

The James Diagonal-Plane Slimer, by S. Arthur Krom, New York, N. Y. (Illustrated by lantern-slides. Discussed by Robert H. Richards.)

*Progress in Roll-Crushing, by C. Q. Payne, New York, N. Y. (A pair of Frazee crushing-rolls showing the even

---

* Pamphlet copies distributed.

effect of wear was exhibited. The paper was discussed by C. Q. Payne, Robert H. Richards, and E. Gybbon Spilsbury.)

Gold Hill Mining-District in Western Utah, by James F. Kemp, New York, N. Y. (Illustrated by lantern-slides.)

Geology of the New Catskill Aqueduct, by Charles P. Berkey, New York, N. Y. Illustrated by lantern-slides.)

The Geology of Certain Salt-Deposits in Western Germany, by F. F. Hahn, New York, N. Y.

The third technical session was held on Wednesday, Feb. 21, at 2 p. m. The following papers were presented in oral abstract by the authors, with the exceptions noted:

Electrolytic Refining of Impure Copper, by Horace H. Emrich, Kyshtim, Russia. (Read by R. W. Raymond. Discussed by Anton Eilers, N. S. Keith, and Albert R. Ledoux.)

*Geology and Ore-Deposits of the Silverbell Mining-District, Arizona, by C. A. Stewart, University of Idaho, Moscow, Idaho. (Read by James F. Kemp.)

Stagnant Mine-Waters, by Alfred C. Lane, Tufts College, Boston, Mass.

The Decomposition of Some Metallic Sulphates at an Elevated Temperature in a Current of Air, by H. O. Hofman and W. Wanjukow, Massachusetts Institute of Technology, Boston, Mass. (Read by H. O. Hofman. Discussed by H. O. Hofman, W. McA. Johnson, and Albert R. Ledoux.

*A Concise Method of Showing Ore-Reserves, by N. H. Emmons, Copperhill, Tenn. (Read by J. D. Irving. Discussed by John D. Irving, N. S. Keith, William Kelly, E. W. King, Charles Kirchhoff, and Alfred C. Lane.

*Fume-Precipitation, by F. G. Cottrell, San Francisco, Cal. (Illustrated by lantern-slides. Discussed by F. G. Cottrell, A. H. Elliott, L. C. Graton, F. W. C. Schniewind, and E. Gybbon Spilsbury.)

A new portable electric mine-lamp and a few photographs showing it in use as a miner's head-light and as a hand-lantern were exhibited at the close of the session. These exhibits were sent by David B. Rushmore to illustrate his paper on Mine-Lamps.

* Pamphlet copies distributed.

The following papers were read by title for future publication by the Institute:

Vanadium in Pig-Iron, by Porter W. Shimer, Easton, Pa.

Temperature Conversion-Tables, by Leonard Waldo, New York, N. Y.

*Treatment of Copper Mine-Water, by Joseph W. Richards, South Bethlehem, Pa.

*Rational Valuation and Quality-Efficiency of Furnace-Stock, by John Jermain Porter, University of Cincinnati, Cincinnati, Ohio.

Bearing of the Theories of the Origin of Magnetic Iron-Ores on Their Possible Extent, by Frank L. Nason, West Haven, Conn.

Geology of Harrison Gulch in Shasta County, Cal., by H. E. Kramm, Ithaca, N. Y.

*Direct Determination of Small Amounts of Platinum in Ores and Bullion, by F. P. Dewey, Washington, D. C.

An Early Discovery of Fuller's Earth in Arkansas, by J. C. Branner, Stanford University, Cal.

Occurrence of Silver-, Copper- and Lead-Ores at the Veta Rica Mine, Sierra Mojada, Coahuila, Mexico, by Frank R. Van Horn, Cleveland, Ohio.

Study of Pre-Cambrian Rocks of the Harney Peak District, South Dakota, by Gordon S. Duncan, London, England.

Treatment of Complex Silver-Ore at the Lucky Tiger Mine, El Tigre, Sonora, Mexico, by D. L. H. Forbes, Toronto, Ont., Canada.

Gold in Certain Copper-Alloys, Soluble in Nitric Acid, by Edward Keller, Perth Amboy, N. J.

Fuel-Economy of Dry-Blast, by R. S. Moore, New York, N. Y.

The St. Helen's Mining District, Skamania County, Wash., by Horace V. Winchell, Minneapolis, Minn.

The San Nicolas Mining-District, by I. H. Wentworth, Matehuala, Mexico.

*Abrasion and Dust-Losses in Ore-Drying, by Carl F. Dietz and Dyke V. Keedy, Boston, Mass.

The Smokeless Coal-Field of West Virginia, by Edwin Ludlow, Eccles, W. Va.

Mine-Lamps, by David B. Rushmore, Schenectady, N. Y.

---

* Pamphlet copies distributed.

The Institute Banquet.

The dinner at the Plaza, on Tuesday evening Feb. 20, was a brilliant and enjoyable affair. The retiring President, Mr. Charles Kirchhoff, presided. Addresses were made by George Otis Smith, Director of the U. S. Geological Survey, who emphasized the cordial relations between that bureau and the Institute, and the mutual helpfulness of their work; Mr. W. L. Saunders, who, having just returned from a journey round the world, spoke interestingly of his observations in the industrial establishments of Europe; and Mr. H. Mortimer Lamb, Secretary of the Canadian Mining Institute, who gracefully expressed the congratulations of his Society. Col. Alexander M. Hay, a Canadian member of the Institute, recited amid laughter and applause a clever poetic burlesque, describing the discovery of the North Pole by a submarine vessel. Dr. Raymond, in responding to the toast of "The Ladies," claimed for the Institute the honor of having been the first national society to have ladies at its banquets, and quoted the following passage from a speech delivered by Alexander L. Holley at the first occasion of this kind, the Pittsburg banquet of 1879:

"Young man of the school, full of lore and anxious for hire, what is the vista of probabilities that fills your eye? Will you map out the metalliferous veins under the fair landscape from the rugged outcrops of the upturned rocks? Will you span the cañon, eroded throughout æons, with your gossamer steel bridge of yesterday? Will you compel a river which denudes a continent to build out its own ship-canal through its own delta with its own débris? Will you sever continents to make a highway for commerce? Will you coax out of ores with your deft alchemy the metals which the evolution of ages put in? Will you drive a train from the Orient to the Occident, following the sun and keeping company with the hours? Ah, my dear boy! these things you may do, but they are only means to an end. And that end you shall see down the long vista of the inevitable. There, with eloquent eyes and folded arms, sits a dear little woman! And, my boy, when those tender arms shall enfold you, and those eloquent eyes shall flash into your soul the potential caloric of a whole life,—*then* you will know what it is to be the lord of a fellow's wife!

"Two thousand years ago, the philosopher Cullimachus, wandering in the cemetery of Corinth, was arrested by a vision of prophetic beauty. It was only an acanthus plant, confined in a basket and covered with a tile, the struggling leaves curling through the meshes and wreathing themselves in graceful volutes under the covering stone. This was the decoration of a child's grave; but it was the prototype of the Corinthian capital. As out of a little grave grew the glory of decorative art, so out of ah! how many little graves, struggling through the meshes and repressed by the cold marble, perennially bloom the graces and the virtues of the higher life—that long-suffering, that patience, that elasticity, that sweetness, that association of the good and the beautiful, which is but another name for the fellows' wives!"

List of Members and Guests (Doubtless Incomplete) Registered at Institute Headquarters.

Adams, George I., Washington, D. C.
Addicks, Lawrence, Chrome, N. J.
Ahbe, F. R., Athens, Pa.
Apgar, Frederick W., Jamaica, N. Y.
Atwater, R. M., Jr., New York, N. Y.
Ayres, W. S., Hazleton, Pa.
Ayres, Mrs. W. S., Hazleton, Pa.
Baker, David, Philadelphia, Pa.
Barbour, Percy E., Candor, N. C.
Barlow, Alfred E., Montreal, Canada.
Barron, George D., New York, N. Y.
Barron, Mrs. George D., New York, N. Y.
Beatty, A. C., New York, N. Y.
Benedict, W. DeL., New York, N. Y.
Bennett, A. F.
Berggreen, Paul.
Berkey, Charles P., New York, N. Y.
Birkinbine, John, Philadelphia, Pa.
Birkinbine, J. L. W., Mexico City, Mex.
Blair, John N., New York, N. Y.
Blair, Mrs. John N., New York, N. Y.
Blow, A. A., New York, N. Y.
Bohn, C. A , New York, N. Y.
Braden, William, New York, N. Y.
Campbell, William, New York, N. Y.
Channing, J. Parke, New York, N. Y.
Ciardi, Mrs. Edward.
Clark, Edward A.
Clark, J. M., Toronto, Canada.
Cogswell, W. B., Syracuse, N. Y.
Cogswell, Mrs. W. B., Syracuse, N. Y.
Conner, Eli T., Philadelphia, Pa.
Cook, Robert A., New York, N. Y.
Cottrell, F. G., San Francisco, Cal.
Cowles, Alfred H., Sewaren, N. J.
Cowles, Mrs. A. H., Sewaren, N. J.
Crosby, W. O., Boston, Mass.
Cumings, W. L., Bethlehem, Pa.
Darlington, Homer T.
D'Audiffret, F., New York, N. Y.
D'Audiffret, Mrs. F., New York, N. Y.
Davis, D. Ashmore.
Davis, L. K., New York, N. Y.
Day, David T., Washington, D. C.
Deiffenbach, E. E., Newark, N. J.
Devereux, W. B., Jr., New York, N. Y.
Doolittle, C. H., Salt Lake City, Utah.
Douglas, James, New York, N. Y.
Drinker, Henry S., Bethlehem, Pa.
DuBois, Howard W., Philadelphia, Pa.
Dufourcq, E. L., New York, N. Y.
Dwight, Arthur S., New York, N. Y.
Dwight, Mrs. A. S., New York, N. Y.
Dwight, Theodore, New York, N. Y.
Earle, R. B.
Edwards, E. J.
Eilers, Anton, Brooklyn, N. Y.
Elliot, A. H., New York, N. Y.
Emanuel, L. V., Perth Amboy, N. J.
Emmons, N. H., Knoxville, Tenn.
Eustis, F. A., Boston, Mass.
Eustis, Mrs. F. A., Boston, Mass.
Ferrier, W. F., Toronto, Canada.
Finlay, James R., New York, N. Y.
Foote, W. B., Geneva, N. Y.
Foucar, E. L., San Francisco, Cal.
Francis, L. W., New York, N. Y.
Freeman, S. S., Parryville, Pa.
French, L. H., New Rochelle, N. Y.
Garrison, F. L., Philadelphia, Pa.
Gouyard, G. M., New York, N. Y.
Graton, L. C., New York, N. Y.
Griffith, William, Scranton, Pa
Hahn, F. F., New York, N. Y.
Hansell, N. V., New York, N. Y.
Hardinge, H. W., New York, N. Y.
Hardinge, Mrs. E. W., New York, N. Y.
Hay, Alexander M., Haileybury, Can.
Hermann, Charles E., New York, N. Y.
Hewett, D. F., Washington, D. C.
Hey, H. A., New York, N. Y.
Hibbard, Henry D., Plainfield, N. J.
Hibbard, Mrs. H. D., Plainfield, N. J.
Hofman, H. O., Boston, Mass.
Holmes, J. A., Washington, D. C.
Holter, E. O., New York, N. Y.
Hothorn, E. G.
Hovey, E. O., New York, N. Y.
Howe, Ernest, Newport, R. I.
Howe, H. M., Bedford Hills, N. Y.
Howe, Mrs. H. M., Bedford Hills, N. Y.
Humphrey, Charles, New York, N. Y.
Humphrey, Mrs. Charles, New York, N. Y.
Humphrey, George S., New York, N. Y.
Humphreys, Alex. C., New York, N. Y.
Ihlseng, A. O., New York, N. Y.
Ingalls, W. R., New York, N. Y.
Irving, J. D., New Haven, Conn.

Janeway, J. H., Jr., New York, N. Y.
Jennings, R. E., New York, N. Y.
Johnesse, Frank E., Boise, Idaho.
Johnson, W. McA., Hartford, Conn.
Jouet, C. H., New York, N. Y.
Kahn, Julius, New York, N. Y.
Keith, N. S., Philadelphia, Pa.
Keith, Miss Vivian, Philadelphia, Pa.
Keller, H. A., New York, N. Y.
Keller, Mrs. H. A., New York, N. Y.
Kelly, William, Vulcan, Mich.
Kemp, J. F., New York, N. Y.
Kennedy, John S., Stanhope, N. J.
Kent, William, Montclair, N. J.
King, E. W., Bozeman, Mont.
King, Paul S., Philadelphia, Pa.
Kirchhoff, Charles, New York, N. Y.
Knight, H. B., New York, N. Y.
Kurtz, E. L., New York, N. Y
Lamb, H. Mortimer, Montreal, Canada.
Lane, A. C.. Tufts College, Mass.
Lane, J. S., New York, N. Y.
Lawrence, Benjamin B., NewYork, N. Y.
Lawrence, Mrs. B. B., New York, N.Y.
Ledoux, A. D., New York, N. Y.
Ledoux, Mrs. A. D., New York, N. Y.
Ledoux, A. R., New York, N. Y.
Leer, I. W. von.
Lidner, P. G., New York, N. Y.
Ludlow, Edwin, Eccles, W. Va.
Lyman, F., New York, N. Y.
Lyon, D. A., Cambridge, Mass.
McClelland, J. F., New Haven, Conn.
McIlvain, E. M., New York, N. Y.
McIntire, R.
Marsters, V. F.
Masters, H. K., Salt Lake City, Utah.
Mathewson, E. P., Anaconda, Mont.
Maynard, George W., New York, N.Y.
Meier, E. D., New York, N. Y.
Meier, Miss, New York, N. Y.
Miller, D. I., Allen's Creek, Tenn.
Miller, W. G., Toronto, Canada.
Moldenke, Richard, Watchung, N. J.
Montgomery, J. C.
Moore, George, Joplin, Mo.
Moore, L. D., Chatham, N. J.
Moore, R. S., New York, N. Y.
Morris, H. C., New York, N. Y.
Mosman, P. A., New York, N. Y.
Nash, H. P., New York, N. Y.
Newland, D. H., Albany, N. Y.
Nichols, W. H., Jr., New York, N. Y.
Norris, R. V., Wilkes-Barre, Pa.
Of, Charles, Palisade, N. J.
Olcott, E. E., New York, N. Y.
Ormrod, George, Emaus, Pa.
Ormrod, J. D., Emaus, Pa.
Paddack, L. E., Duluth, Minn.
Partz, J. L., Philadelphia, Pa.
Patterson, S. B., Robesonia, Pa.
Payne, C. Q., New York, N. Y.
Prosser, H. A., New York, N. Y.
Raymond, R. W., New York, N. Y.
Raymond, Mrs. R. W., New York, N.Y.
Rice, Calvin W., New York, N. Y.
Richards, Joseph W., S. Bethlehem, Pa.
Richards, Robert H., Boston, Mass.
Ridgway, Robert.
Riordan, D. M., New York, N. Y.
Roeber, E. F., New York, N. Y.
Rogers, William B., New York, N. Y.
Rowands, Lewis G., New York, N. Y.
Ruhl, Louis, New York, N. Y.
Ryall, George M.
Sanders, R. H., Philadelphia, Pa.
Saunders, W. L., New York, N. Y.
Sauveur, Albert, Cambridge, Mass.
Scaife, H. L., Clinton, S. C.
Scallon, William, New York, N. Y.
Schniewind, F., New York, N. Y.
Sears, Stanley C., Parral, Mexico.
Semple, C. C., New York, N. Y.
Sharpless, F. F., Westbury Sta., N. Y.
Sharpless, Mrs. F. F., Westbury Sta., N. Y.
Shaw, S. F., New York, N. Y.
Shenstone, A. C., New York, N. Y.
Sherrerd, J. M., Easton, Pa.
Shipp, E. M., Newburgh, N. Y.
Shurick, H. E., New York, N. Y.
Shurick, A. T., New York, N. Y.
Sinclair, J. H.
Smith, E. P., New York, N. Y.
Smith, George O., Sydney, Australia.
Smith, H. I., Pittsburg, Pa.
Smyth, H. L., Watertown, Mass.
Spilsbury, E. Gybbon, New York, N.Y.
Stanton, Robert B., New York, N. Y.
Stevens, Blamey, Penticton, Canada.
Stone, George C., New York, N. Y.
Stoughton, Bradley, New York, N. Y.
Stoughton, Mrs. B., New York, N. Y.
Strong, A. H., New York, N. Y.
Struthers, Joseph, New York, N. Y.

Sussmann, Otto, New York, N. Y.
Taylor, H. B., Kansas City, Mo.
Taylor, Knox, High Bridge, N. J.
Taylor, Mrs. Knox, High Bridge, N. J.
Taylor, S. A., Pittsburg, Pa.
Thompson, A. P.
Tillson, Benj. F., Franklin Furnace, N. J.
Torrey, H. G., New York, N. Y.
Torrey, Mrs. H. G., New York, N. Y.
Vail, Richard H., New York, N. Y.
Van Mater, J. A., New York, N. Y.
Van Winkle, Edward.
Vogel, F. A., New York, N. Y.
Vogelstein, Ludwig, New York, N. Y.
Von Baur, C. H., New York, N. Y.
Waldo, Leonard, New York, N. Y.
Walker, Arthur L., New York, N. Y.
Weed, Walter H., New York, N. Y.
Wentworth, Henry A., Boston, Mass.
Wethey, A. H., New York, N. Y.
Weisenburg, Andrew.
White, James, New York, N. Y.
Wilcox, George, Bridgeport, Conn.
Wilkins, H. A. J., New York, N. Y.
Wilkes, S. M.
Williams, Gardner F., Washington, D.C.
Willis, H. T., Champaign, Ill.
Winslow, Arthur, Boston, Mass.
Witherell, C. S., Newark, N. J.
Woodman, J. E., New York, N. Y.
Worth, John G., New York, N. Y.
Worth, Mrs. John G., New York, N. Y.

No. 64 APRIL 1912

Bulletin of the American Institute of Mining Engineers.

CONTENTS:

SECTION I.—INSTITUTE ANNOUNCEMENTS.

SECTION II.—PAPERS AND DISCUSSIONS.

BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

No. 64 APRIL 1912

PUBLISHED MONTHLY
BY THE AMERICAN INSTITUTE OF MINING ENGINEERS
at 124 to 128 N. Seventh St., Philadelphia, Pa.
Guy R. Overend, Publication Manager.

Editorial Office, 29 West 39th St., New York, N. Y.

JOSEPH STRUTHERS, Ph.D., Editor.

Cable address, "Aime," Western Union Telegraph Code.

Subscription (including postage), $10 per annum; to members of the Institute, public libraries, educational institutions and technical societies, $5 per annum.

Single copies (including postage), $1 each; to members of the Institute, public libraries, etc., 50 cents each.

Entered as second class matter, October 16, 1911, at the post office at Philadelphia, Pa., under the Act of March 3, 1879.

TABLE OF CONTENTS.

SECTION I. INSTITUTE ANNOUNCEMENTS.

SECTION II. TECHNICAL PAPERS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

All communications concerning the contents of this Bulletin should be addressed to JOSEPH STRUTHERS, Ph.D., Secretary and Editor, 29 W. 39th St., New York, N. Y.

OFFICERS.

For the year ending February, 1913.

COUNCIL.*

PRESIDENT OF THE COUNCIL.

JAMES F. KEMP..NEW YORK, N. Y.

(Term expires February, 1913.)

VICE-PRESIDENTS OF THE COUNCIL.

S. B. CHRISTY..BERKELEY, CAL.
W. A. LATHROP..PHILADELPHIA, PA.
GARDNER F. WILLIAMS..WASHINGTON, D. C.

(Term expires February, 1913.)

KARL EILERS..NEW YORK, N. Y.
WALDEMAR LINDGREN..WASHINGTON, D. C.
BENJAMIN B. THAYER...NEW YORK, N. Y.

(Term expires February, 1914.)

COUNCILORS.

ROBERT E. JENNINGS...NEW YORK, N. Y.
WILLIAM KELLY..VULCAN, MICH.
——— ———..———— ————.

(Term expires February, 1913.)

A. E. CARLTON..CRIPPLE CREEK, COLO.
W. J. OLCOTT...DULUTH, MINN.
E. L. YOUNG..NEW YORK, N. Y.

(Term expires February, 1914.)

JOHN H. JANEWAY, JR..NEW YORK, N. Y.
SIDNEY J. JENNINGS...NEW YORK, N. Y.
JOSEPH W. RICHARDS...SOUTH BETHLEHEM, PA.

(Term expires February, 1915.)

SECRETARY OF THE COUNCIL AND EDITOR.

JOSEPH STRUTHERS, 29 W. 39th St......................................NEW YORK, N. Y.

(Term expires February, 1913.)

SECRETARY EMERITUS OF THE COUNCIL.

R. W. RAYMOND..NEW YORK, N. Y.

CORPORATION.

JAMES F. KEMP, President; EDMUND B. KIRBY, Vice-President;
FRANK LYMAN, Treasurer; GEORGE C. STONE, Secretary;
JOSEPH STRUTHERS, Assistant Secretary and Assistant Treasurer.

DIRECTORS.

JAMES GAYLEY, CHARLES KIRCHHOFF, FRANK LYMAN.

(Term expires February, 1913.)

JAMES DOUGLAS, JAMES F. KEMP, ALBERT R. LEDOUX.

(Term expires February, 1914.)

EDMUND B. KIRBY, CHARLES F. RAND, GEORGE C. STONE.

(Term expires February, 1915.)

Consulting Attorneys, Blair & Rudd, New York, N. Y.

---

* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation.

COMMITTEES.

For the year ending February, 1913.

COUNCIL.

Membership:—Joseph Struthers, Karl Eilers, Sidney J. Jennings, Benjamin B. Thayer, ———— ————.

Publications:—Joseph Struthers, *Chairman*, New York, N. Y.; David W. Brunton, Denver, Colo.; Samuel B. Christy, Berkeley, Cal.; Albert L. Colby, South Bethlehem, Pa.; Nathaniel H. Emmons, Copperhill, Tenn.; Charles H. Fulton, Rapid City, S. D.; James Gayley, New York, N. Y.; H. O. Hofman, Jamaica Plain, Mass.; Henry M. Howe, Bedford Hills, N. Y.; Walter R. Ingalls, New York, N. Y.; James F. Kemp, New York, N. Y.; R. V. Norris, Wilkes-Barre, Pa.; Edward D. Peters, Dorchester, Mass.; Rossiter W. Raymond, New York, N. Y.; Joseph W. Richards, South Bethlehem, Pa.; Robert H. Richards, Boston, Mass.; Albert Sauveur, Cambridge, Mass.; Henry L. Smyth, Watertown, Mass.; Arthur L. Walker, New York, N. Y.

CORPORATION.

Finance:—Charles F. Rand, James Gayley, George C. Stone.

Library:—James F. Kemp, Charles Kirchhoff, George C. Stone.

Land Fund:—James Douglas, *Chairman*; Theodore Dwight, *Treasurer*; T. F. Cole, Anton Eilers, James Gayley, John Hays Hammond, Charles Kirchhoff, Albert R. Ledoux, Frank Lyman.

INSTITUTE REPRESENTATIVES.

United Engineering Society Trustees:—Joseph Struthers (1913), Theodore Dwight (1914), James F. Kemp (1915).

Joint Conference Committee of the Four National Engineering Societies:—James F. Kemp, Joseph Struthers.

John Fritz Medal Board of Award:—E. Gybbon Spilsbury (1913), R. V. Norris (1914), Charles Kirchhoff (1915), J. F. Kemp (1916).

American Association for the Advancement of Science:—H. O. Hofman, Boston, Mass.; John D. Irving, New Haven, Conn.

Eighth International Congress of Applied Chemistry, New York, September, 1912:—William L. Saunders, New York, N. Y.; George C. Stone, New York, N. Y.

International Association for Testing Materials Congress, Chicago, September, 1912:—Robert Forsyth, Chicago, Ill.

Committee No. 24, International Association for Testing Materials:—Henry D. Hibbard, Plainfield, N. J.

International Engineering Congress, San Francisco, 1915:—Samuel B. Christy, William C. Ralston, Edwin T. Blake.

INSTITUTE ANNOUNCEMENTS.

Newly-Elected Officers of the Board of Directors and the Council.

JAMES FURMAN KEMP,

President of the Board of Directors and President of the Council.

James Furman Kemp was born in the city of New York, Aug. 14, 1859, and is therefore in his fifty-third year. Soon after his first birthday his parents moved to Brooklyn. In time he was placed in the Adelphi Academy of that city and practically remained in it until his graduation in 1876. A year later, in the fall of 1877, he entered Amherst College, and was graduated in 1881. Amherst was one of the first of the New England colleges to give to the various branches of science a prominent place in the curriculum. Edward Hitchcock, one of its earlier presidents, was State Geologist of Massachusetts, and brought out, in 1831, the first of the comprehensive State reports. The tradition of geological instruction was maintained in Amherst College by his successors, and when the subject of this sketch came under the instruction of Prof. B. K. Emerson, the present inspiring incumbent of the Chair of Geology, he determined to follow the science as a profession. During his undergraduate days a wave of mining excitement swept through the little town of Amherst, and in subsiding left the usual financial wreckage behind. So much loss and hardship were occasioned by it, that young Kemp was led towards the mining and economic side as a special line of work. To find ultimately a teacher's chair and to disseminate sound views on ore-deposits and the useful minerals became a fixed purpose while he was yet in college. On leaving Amherst, Kemp entered the Columbia School of Mines, and, while taking the full course in mining engineering, spent such spare hours as he could command in the collection of ores and in special work under Prof. J. S. Newberry, who was then one of the two or three American professors who gave instruction in this side of geology. Professor and student became profoundly attached to each other, and in 1885, a year after Kemp had taken his degree of Engineer of Mines, the two traveled to Europe together for the International Geological Congress in Berlin. Professor Newberry returned in the fall, and his old student remained for work in geology and petrography, settling at Munich as a pupil of v. Groth, v. Zittel, and their younger colleagues.

An instructorship opening at Cornell the following year, Kemp received the call and, as assistant in the department with Prof. H. S. Williams, began instructing engineers and giving work in petrography to graduate students. Ultimately mineralogy was transferred from the Department of Chemistry and was also taught by him.

After five years' service at Cornell, the illness of Professor Newberry made a younger man necessary at Columbia, and Assistant-Professor Kemp was called to the position. The next year he became full Professor and has remained in this capacity for the past twenty years. Professor Kemp's great interest has been on the mining and economic side of the subject. He has taught mining engineers and graduate students more particularly in these lines. He has traveled extensively, as one must to teach the subject properly, and has been repeatedly in the West, Canada, and Mexico. In his early instruction, finding no book which was available for his students as a text-book, he prepared the *Ore-Deposits of the United States*, endeavoring to make for American students a work analogous to the text-book of v. Cotta, or more particularly the later one of v. Groddeck. The results of travel and reading for the preparation of the book convinced its author that igneous rocks were extremely important factors in the formation of veins, even though his earlier instruction from Professor Newberry tended in the opposite direction. Time has, however, abundantly proved the soundness of these conclusions. Indeed, it is difficult to see any other possible conclusion when an observer is familiar with the phenomena as displayed in western North America.

Professor Kemp became a member of the Institute in 1891, was a Vice-President in 1903–04, Manager, 1896–98, and Director from 1905 to date. He was one of the nine incorporators when the Institute took out its charter in 1905. He has been a frequent contributor to the *Transactions*, and for twenty years has been profoundly interested in the welfare and progress of the society. He has been twice President of the New York Academy of Sciences, and of the Alumni Association of the Columbia School of Mines, and was elected to the National Academy of Sciences last year.

EDMUND B. KIRBY,

Vice-President of the Board of Directors.

Edmund B. Kirby was graduated from Washington University, St. Louis, in 1884, as a mining engineer and metallurgist, receiving the degree of M. E.

For several years after graduation he worked as assayer and chemist at smelting-plants in Arizona and Colorado, and as an ore-buyer in Leadville and Denver. Later he built the lead-smelting plant of the Philadelphia Smelting & Refining Co. at Pueblo, Colo., while Superintendent of that company. He was Superintendent of the Russell Process Silver Lixiviation Mill at Aspen, Colo.

Subsequently he was engaged in consulting engineering practice throughout the West, with headquarters at Denver, and for two years he delivered lectures on mining and metallurgy at the State School of Mines at Golden, Colo. Later, during a period of five years he was General Manager of the War Eagle & Center Star Mining Co. at Rossland, B. C., followed by independent business in Nevada, and for about two years in the service of the American Smelters & Securities Co. as Manager of the Federal Lead Co., operating lead-mines, mills and a railroad at Flat River, Mo.

At the present time Mr. Kirby is in consulting practice, and has an office at 701 Security Building, St. Louis, Mo.

He has been a member of the Institute since 1884, and is also a member of the Mining and Metallurgical Society of America, the Canadian Mining Institute and the Colorado Scientific Society.

GEORGE C. STONE,

Secretary of the Board of Directors.

George Cameron Stone, after preparation in the schools near New York, entered the School of Mines of Columbia University and was graduated in the course in Chemistry in the class of 1879. For a year he served as chemist in the Booth & Edgar sugar refinery and then entered the service of Potter & Riggs, St. Louis, of which William B. Potter, past President of the Institute, was senior partner. Mr. Stone remained three years in St. Louis, acquiring a varied experience in metallurgical chemistry. In 1882 he became chemist with the New Jersey Zinc Co., at the plant then and for many years active in Newark, N. J. Two years later he was advanced to the position of Superintendent of blast-furnaces, and had the oversight of the difficult process of smelting spiegeleisen from the clinker of the zinc-oxide furnaces, working on franklinite and associated minerals. Ten years later he became Superintendent for the company, and remained in this position during the consolidation of all the interests operating the mines at Franklin Furnace and Ogdensburg, N. J. In 1900 Mr. Stone became Chief Engineer. The old works at Newark and on the meadows west of Jersey City were abandoned, and a very extensive new plant was built at Palmerton in the Lehigh valley. Affiliated interests of the New Jersey Co. also have works in the Mississippi valley and in Colorado, so that Mr. Stone's duties have taken him as far west as the Rocky mountains. In former years he has contributed to the *Transactions* upon subjects related to zinc and manganese. He has also been active in the American Chemical Society. Mr. Stone joined the Institute in 1880.

WALDEMAR LINDGREN,

Vice-President of the Council.

Waldemar Lindgren was born in Kalmar, Sweden, Feb. 14, 1860. After the usual training, he entered the famous old Mining Academy at Freiberg, in Saxony and received the degree of mining engineer in 1883. Having decided to cast his lot in the United States, he came to this country and found his first engagement on the Northern Trans-Continental Survey, which, under the direction of Raphael Pumpelly, and in the interests of the Northern Pacific R. R., was investigating the mineral resources, especially coal, along the railway's line. The results were afterward published in Vol. XV. of the Tenth Census. Part of the following year Mr. Lindgren was chemist of the Gregory smelter, in Montana, but before its close entered the service of the U. S. Geological Survey as assistant geologist. Mr. Lindgren's preparation at Freiberg naturally led him into the mining side of the Survey's work, and as the years passed his name appeared more and more frequently as the author

of independent papers. He became an accomplished petrographer from his studies of Western rocks. In 1895 he was made geologist, and in 1907 was placed in charge of all the investigations of the Survey in metalliferous deposits and metal statistics. All members of the Institute are familiar with the valuable services rendered in these publications in later years. In November, 1911, he was appointed Chief Geologist of the Survey, under the Director, succeeding Dr. C. W. Hayes. Mr. Lindgren has been a prolific writer upon a wide range of mining-districts in the West, embracing the gold-belt of the Sierras; various camps in Idaho; Cripple Creek, Colo.; Morenci, Ariz.; New Mexico as a whole, and at present, Tintic, Utah. He has also served as Associate Professor of Mining and Metallurgy in Stanford University, 1898, and as Lecturer on Economic Geology at the Massachusetts Institute of Technology, 1908–12. He is a member of the National Academy of Sciences, a Fellow of the Geological Society of America, and is connected with other scientific societies. Mr. Lindgren has been a frequent contributor to our *Transactions*. His two papers, Metasomatic Processes in Fissure-Veins, 1901, and The Geological Features of the Gold-Production of North America, 1903, are in their department among the most important in our publications. Mr. Lindgren became a member of the Institute in 1900.

BENJAMIN B. THAYER,

Vice-President of the Council.

Benjamin Bowditch Thayer was born in San Francisco, Cal., in the year 1862. He was prepared for Harvard University at Quincy, Mass., and was graduated from the Lawrence Scientific School in 1885. On leaving college the call of the West drew him into mining in the Rocky mountains of the United States and the Sierra Madre in Mexico. After years of experience in underground work and in administrative relations in a number of mining-districts, he became especially identified with copper-mining in Butte and has been in later years President of the Anaconda Copper Mining Co. Thoroughly familiar with both the workings underground and the operations on the surface, and with all phases of the mining profession, and further provided with a knowledge of what good team-work means in an organization, Mr. Thayer has infused into his great company a loyalty and an efficiency that are exceptional. Mr. Thayer is one of the advisory committee upon the conduct and development of mining education at Harvard, and has served as President of the New York Society of Harvard Engineers. In the matters affecting the alumni of his alma mater he has been very active. Mr. Thayer became a member of the Institute in 1887.

JOHN H. JANEWAY, JR.,

Member of the Council.

John H. Janeway, Jr., obtained his technical education at the School of Mines, Columbia College, and was graduated therefrom, with the class of 1886, in the course of mining engineering, receiving the degree of E. M. Following his graduation, he was for five

years employed by Cooper, Hewitt & Co. and the Trenton Iron Co., and from 1891 to 1905, he occupied the position of engineer and metallurgist for the firm of John A. Roebling's Sons. From 1905 to date he has been the General Manager of the Mineral Point Zinc Co. Mr. Janeway became a member of the Institute in 1886.

SIDNEY J. JENNINGS,

A Member of the Council.

Mr. Sidney J. Jennings was born at Hawesville, Hancock county, Ky., Aug. 13, 1863. His early education was obtained in France and Germany, and he was graduated from the Lawrence Scientific School, Harvard University, in 1885 with the degree of C. E. During the next four years Mr. Jennings worked as surveyor for the New Almaden Quicksilver Co. and the Anaconda Copper Co. For a time he was assistant superintendent of a syndicate which was engaged in the interesting experiment of tunneling along the bed-rock of the Feather river at Oroville, keeping the water out of the gravel-tunnels by means of compressed air. In 1889 he went to South Africa as Manager of the Willows Copper Argentiferous Syndicate. At this property he erected the first two reverberatory furnaces for the smelting of copper-ores in South Africa. Owing to the change of the ore in depth from copper carbonate, carrying a large quantity of silver to an iron carbonate, carrying a small quantity of silver, the enterprise was not a financial success, and Mr. Jennings resigned and shortly afterwards was appointed Assistant General Manager of the De Beers Consolidated Mines, the corporation which controls the major portion of the output of diamonds of the world. Under the general management of Mr. Gardner F. Williams, Mr. Jennings introduced many economies in working the blue ground, and greatly increased the speed of sinking shafts and driving rock and cuts that obtained at that date.

Mr. Jennings left Kimberley in 1893 to accept the position of Manager of the Crown Deep, Ltd., one of the subsidiary "Deep Level" companies of the Rand mines, at Johannesburg. Here Mr. Jennings established a record for the fast driving of tunnels in rock which was not excelled in South Africa for many years. In 1896 Mr. Jennings was appointed General Manager of the Crown Reef Gold Mining Co., a position which he held for three years. Mr. Jennings during his management, with Mr. Hennen Jennings as Consulting Engineer, more than doubled the profits of the company by introducing the sorting-out of waste rock, and extending the contract-system of paying for work.

In 1899 Mr. Jennings was appointed Consulting Engineer to the Robinson Gold Mining Co., at that time the largest gold-producing mine in South Africa, and also was appointed Assistant Consulting Engineer to Messrs. H. Eckstein & Co., the largest mining firm in South Africa.

On the outbreak of the Boer War Mr. Jennings went to Europe, but returned to South Africa in time to accompany the first party of consulting engineers who were allowed to go to Johannesburg. Owing to the lamented death of Mr. Louis Seymour, who was killed at the battle of Sand River, the position of Consulting Engineer to

Messrs. H. Eckstein & Co. was vacant, and Mr. Jennings was appointed to fill it. Later on Mr. Jennings was made chief technical adviser to that firm. At the time Mr. Jennings left South Africa, in 1907, Messrs. Eckstein & Co. controlled the technical administration of companies that contributed almost 40 per cent. of the gold-output of South Africa, and these companies employed 48,000 Chinese and Kaffirs, and 6,000 white men. The building-up of this vast industry from the practical shut-down caused by the war was an immense task, and required the enthusiastic co-operation of the capitalist, the engineer, and the worker.

Mr. Jennings was appointed by Lord Milner to the Town Council of Johannesburg, and was elected Chairman of the Works Committee. This committee had charge of the works that provided Johannesburg with an adequate water-supply, sewers, a municipally-owned electric tramway, and helped to change it from an overgrown village into an up-to-date city.

In 1907 Mr. Jennings left South Africa and returned to America, where he established himself as a consulting engineer in New York. He was for almost two years Consulting Engineer of the Boston Consolidated up to its absorption by the Utah Copper Co. He is now Vice-President of the United States Smelting, Refining & Mining Co., and has charge of the Exploration Department of that company, and passes upon the acquisition of all properties.

Mr. Jennings was President of the South African Association of Engineers, Vice-President of the South African Association for the Advancement of Science, and he is a member of the Chemical, Metallurgical and Mining Society of South Africa, corresponding member of the Council of the Mining and Metallurgical Institute of London, member of the Institute of Mining and Metallurgy of the United States, and a life member of the American Institute of Mining Engineers.

Acts of the Council.

The following notes from the minutes of the meeting of the Council, Mar. 22, 1912, are here published for the information of the members:

Appointment of Committee on Membership for the ensuing year: Joseph Struthers, *Chairman*, B. B. Thayer, Karl Eilers, S. J. Jennings (one additional member yet to be appointed).

Additional appointments on the Kelvin Memorial Committee: Dr. James Douglas and Prof. Samuel B. Christy (the complete committee being Prof. James F. Kemp, *Chairman*, Dr. James Douglas, Prof. Samuel B. Christy, and Dr. Joseph Struthers).

By-Laws of the Spokane Local Section, American Institute of Mining Engineers.

(*Approved Jan.* 12, 1912.)

ARTICLE I.—MEMBERSHIP.

All members of the American Institute of Mining Engineers residing or doing business within the boundaries of the following described territory are members of the Spokane Local Section :

Beginning at the International boundary (49th parallel north) and the 115th Meridan west ; thence south to parallel 45 north ; thence west to Snake river ; thence southerly along said river to the southern city-limits of Huntington, Oregon ; thence west to the 120th Meridan west ; thence north to the Columbia river ; thence westerly to the western city-limits of White Salmon, Wash. ; thence north to the summit of the Cascade mountains ; thence northerly along said summit to a point directly east of the south city-limits of Hope, B. C. ; thence west to the west bank of Frazer river ; thence northerly and easterly along the main-line of the Canadian Pacific railway, including all points on that line to the summit of the Rocky mountains ; thence southerly along said summit to the United States boundary-line ; thence west to the point of beginning.

ARTICLE II.—OFFICERS AND COMMITTEES.

The officers of this Section shall be a Chairman, a Vice-Chairman, and a Secretary-Treasurer.

The above officers, together with the Chairman of the year preceding and one other member, chosen by these four, shall constitute the Executive Committee of the Section.

The Secretary and two other members of the Executive Committee shall constitute a Program Committee.

ARTICLE III.—ELECTION OF OFFICERS.

The officers shall be elected for a period of one year, at the annual meeting of the Section in September or October. The Secretary shall invite nominations for these officers in sending out notices of the said meeting ; such nominations may be mailed to the Secretary, or handed to him in writing at the meeting. Each member shall make only one nomination for each office.

At the annual meeting, the Secretary shall post and announce a tabulation of the nominations. The members present shall then elect the officers by ballot, upon slips distributed for the purpose.

ARTICLE IV.—VACANCIES.

Vacancies in the offices, or in the Executive Committee, shall be filled by the Committee.

ARTICLE V.—EXPENSES.

Any expenses incurred in a year in excess of the appropriations which may be made to the Section in that year by the Institute, shall be made up by voluntary subscriptions.

ARTICLE VI.—MEETINGS.

The regular meetings of the Section shall be the annual meeting as hereabove provided, and three other meetings during the year, dates of which will be fixed by the Executive Committee. Other meetings may be arranged by the Executive Committee or shall be called upon the written request of five members.

The annual meeting shall be held in Spokane, place of other meetings to be determined by the Executive Committee.

At all meetings, properly announced, those present shall constitute a quorum for the transaction of business.

The Secretary shall announce the program of the meetings, for the annual meeting two weeks in advance, and to include announcement of elections to take place, and for other meetings one week in advance.

Special meetings may be called at any time by any two members of the Executive Committee.

The Executive Committee may omit a meeting for satisfactory reasons.

ARTICLE VII.—BUDGET.

The newly-elected Executive Committee, at its first meeting after the annual meeting, shall make an estimate of the probable necessary running expenses of the Section for the coming year, and communicate this to the Secretary of the Institute.

ARTICLE VIII.—ORDER OF PROCEDURE.

1. Reading of Minutes.
2. Reports of Officers and Committees.
3. Unfinished Business.
4. Election of Officers at Annual Meetings.
5. New Business and Communications.
6. Reading of Papers and Discussions.
7. Adjournment.

ARTICLE IX.—AMENDMENTS.

Amendments and alterations to these By-Laws may be made by a two-thirds vote of the members voting at a regular meeting, provided the text of the proposed change be sent with the notice of the meeting.

ARTICLE XI.—ORGANIZATION.

At the first meeting of the Spokane Section, called for organization and the election of officers, the members present shall elect a Chairman, Vice-Chairman, Secretary-Treasurer, and the two other members of the Executive Committee, to serve until the next annual meeting.

Signed by the Committee Nov. 24, 1911.

FRANCIS A. THOMSON.
(Signed): C. A. STEWART.
G. A. COLLINS.

Adopted by unanimous vote of members present at meeting, Spokane, Nov. 24, 1911.

L. K. ARMSTRONG, *Secretary.*

Approved by the Chairman.
RICHARD S. MCCAFFERY.

By-Laws of the Boston Section, American Institute of Mining Engineers.

(*Approved March* 22, 1912.)

ARTICLE I.—NAME.

The name of this Section shall be, the Boston Section of the American Institute of Mining Engineers.

ARTICLE II.—MEMBERSHIP.

All the members of the American Institute of Mining Engineers residing or doing business in the New England States, except Connecticut, are members of this Section.

ARTICLE III.—OFFICERS AND COMMITTEES.

The officers of this Section shall be a Chairman, a Vice-Chairman, and a Secretary-Treasurer.

The above officers, and two members chosen by them, shall constitute the Executive Committee.

The Secretary and two other members of the Executive Committee shall constitute a Program Committee.

ARTICLE IV.—ELECTION OF OFFICERS.

1. The officers shall be elected for a period of one year at the annual meeting of the Section. The Secretary shall invite nominations for these officers in sending out notices of the said meeting; such nominations may be mailed to the Secretary,

or handed to him in writing at the meeting. Each member shall make only one nomination for each office.

2. At the annual meeting, the Secretary shall post and announce a tabulation of the Nominations. The members present shall then elect the officers by ballot, upon slips distributed for this purpose.

ARTICLE V.—VACANCIES.

Vacancies in the offices shall be filled by the Executive Committee.

ARTICLE VI.—MEETINGS.

1. A regular meeting shall be held on the first Monday of each month, except June, July, August, and September. The place of meeting shall be arranged by the Executive Committee.

2. The regular meeting in March shall be the annual meeting.

3. At all regular meetings, properly announced, one officer and four other members shall constitute a quorum for the transaction of business.

4. The Secretary shall send written notice of all ordinary meetings, including the program, to each member, at least one week in advance. Notice of the annual meeting shall be sent at least two weeks in advance.

5. Special meetings may be called at any time by any two members of the Executive Committee.

6. The Executive Committee may omit a regular meeting for sufficient reason.

ARTICLE VII.—BUDGET.

The newly-elected Executive Committee, at its first meeting after the annual meeting, shall make an estimate of the probable necessary running expenses of the Section for the coming year, and communicate this to the Secretary of the Institute.

ARTICLE VIII.—ORDER OF PROCEDURE.

1. Reading of Minutes.
2. Reports of Officers and Committees.
3. Unfinished Business.
4. Election of Officers at Annual Meeting.
5. New Business and Communications.
6. Reading of ~~Papers and Discussions~~.
7. Adjournment.

ARTICLE IX.—AMENDMENTS.

Amendments and alterations to these By-Laws may be made by a two-thirds vote of the members voting at a regular meeting, provided the text of the proposed change be sent with notice of that meeting.

R. H. RICHARDS, *Chairman.*
H. O. HOFMAN.
A. SAUVEUR.
H. L. SMYTH.
A. C. LANE.
A. H. EUSTIS.

Library Research-Work.

The attention of members of the Institute is again directed to the research-work done by the librarian and his assistants, which should attract special attention from those members who have no access to the literature of subjects in which they may be interested.

During the year 1911 there were 143 searches made for members and non-members of the Founder Societies, and copies of the references have been preserved for the use of others. This work has been largely based on requests sent in by mail, from Japan, South

Africa, Mexico, Canada, and England, as well as from different parts of the United States. The Librarian is confident that if it were more widely known that the library is equipped to undertake researches, the demand would increase beyond the ability of the present force to handle it. The library receives more than 700 technical periodicals which are available through the indexes for this special purpose.

Back Volumes of the Transactions.

The Board of Directors has authorized the following offers of sets of back volumes of the *Transactions*, at considerably reduced prices, to Members, Libraries, and Scientific Societies:

		Per Set.
I.	Five volumes, bound in half-morocco, from No. 36 (1906) to No. 40 (1910), ...	$20
II.	Ten volumes, bound in half-morocco, from No. 31 (1902) to No. 40 (1910), including Mexican Volume, . .	35
III.	Twenty volumes, bound in half-morocco, from No. 21 (1893) to No. 40 (1910), ...	50
IV.	Thirty volumes, bound in half-morocco, from No. 11 (1883) to No. 40 (1910), ...	60
V.	Thirty-nine volumes, bound in half-morocco, from No. 1 (1873) to No. 40 (1910), with the exception of No. 10 (1882), but including index for Volumes Nos. 1 to 35, and Nos. 36 to 40, ...	75
VI.	Nine volumes, bound in half-morocco, from No. 1 (1873) to No. 9 (1881), ...	25

Applications should be addressed to Joseph Struthers, Secretary, 29 West 39th Street, New York, N. Y.

Special Notice.

The *Bulletin* is now entered at the Post Office at Second-Class Postage rate of one cent per pound, and in order to preserve this privilege it will be necessary that the dues of members be paid within four months of Jan. 1, 1912. If the dues are not paid within the period mentioned, a member's name must be removed from the regular subscription-list and the *Bulletin* mailed at the transient second-class postage rate of one cent for each four ounces or fraction thereof, prepaid by stamps affixed. It is therefore earnestly requested that dues be paid promptly—otherwise the Institute will be put to additional expense of postage and to added labor in removing and replacing names from the regular list, and in maintaining an additional separate mailing-list.

Local Sections.

The following regulations for the establishment of Local Sections of the Institute, issued in circular form and distributed to the membership May 26, 1911, are here republished for more convenient reference.

Regulations for the Formation and Conduct of Local Sections.
(Adopted May 19, 1911.)

1. A Local Section of the Institute may be authorized by the Council at the written request of *ten* members residing within an appropriate distance of a central point.
2. Only one Section shall be authorized in one locality or district.
3. The Council shall define the territory of a Section.
4. A Section must consist of twenty-five or more members; when its membership falls below twenty-five in number the Council may annul the Section.
5. Only members of the Institute shall be members of its Local Sections.
6. All members of the Institute, of all grades, residing within the territory of a Section shall *ipso facto* constitute the membership of such Section.
7. The officers of a Section shall be elected after the formation of the Section has been duly authorized, at a meeting of the members of the Institute within the territory of said Section, called by the sponsors of the Section, notice of said meeting and its object being given to said members at least thirty days in advance. Officers shall be elected for a term not longer than one year.
8. The officers of a Local Section shall be a Chairman, Vice-Chairman, Secretary, Treasurer (or Secretary-Treasurer), and such others as the Section may desire.
9. Whenever the Institute is financially able to do so, it shall be the policy of its Board of Directors to contribute from its funds for the legitimate running expenses of each Local Section an amount not exceeding, in each year, 25 per cent. of the dues received from the members of said Section in said year. Requests for such appropriations shall be signed by the Chairman, Secretary and Treasurer of the Section.
10. If the expenses of a Section exceed the appropriation made it by the Institute, the difference must be made up by voluntary contributions, but not by assessment upon the members of said Section. The Institute shall not be responsible for the debts of its Sections.
11. The Institute reserves the right to cancel a Section, or re-adjust its territory.
12. Papers presented at Local Sections, and discussions thereon if reported, are the property of the Institute. They shall be submitted to the Publication Committee and published in the *Bulletin* or *Transactions*, or both, if approved. Such papers shall not be published elsewhere without permission of the Council. The reading of a paper before a Local Section shall not carry with it the right of publication in the *Bulletin* or *Transactions* of the Institute.
13. Neither the author of a paper presented to a Local Section nor the Local Section shall have the right to reprint a paper or publish it in advance of the meeting without obtaining the permission

of the Publication Committee of the Institute, which shall determine the details of such permission. Nothing herein shall forbid the abstracting of a paper by the press *after* its presentation before the Local Section.

14. The Institute shall print advance copies of papers offered to Local Sections, in order to facilitate discussion thereon, provided that such papers are approved for such advance publication by the Chairman or Secretary of the Local Section and by the Publication Committee of the Institute.

15. Papers read before a Local Section may also be offered for reading or discussion at general meetings of the Institute, and shall be given equal standing with the other papers on the program of said meeting, when approved by the Publication Committee.

16. Each Local Section shall transmit promptly to the Secretary of the Institute full announcements of its proposed meetings and an abstract of its proceedings, including the names of authors and titles of all papers read before it, for the purpose of preparing a report thereon to be published in the *Bulletin* of the Institute, and for the purpose of enabling the Council of the Institute to comply with articles 17 and 19 of these regulations.

17. The By-Laws and regulations of Local Sections shall be subject to the approval of the Council.

18. The Council reserves the right to amend, annul, or add to these regulations.

19. No action shall be taken by a Section which shall contravene the Constitution of this Institute.

The Emmons Research Fellowship of Economic Geology.

The Committee named below has been formed by friends of Samuel Franklin Emmons, late of the United States Geological Survey, to consider the best method of perpetuating his name. It has been decided that the memorial to him shall take the shape of a Research Fellowship, to be known as the Samuel Franklin Emmons Research Fellowship of Economic Geology, which is to be administered by Prof. James F. Kemp, of Columbia University, New York. Subscriptions are invited by his friends to this fund, which the Committee has fixed at $25,000.

Members of the Institute who desire to contribute to this fund will please communicate with the Treasurer, Benjamin B. Lawrence, 60 Wall Street, New York.

The Committee consists of the following:

GEORGE OTIS SMITH, Director, U. S. Geological Survey, Washington, D. C.

H. L. SMYTH, Harvard University, Cambridge, Mass.

JAMES DOUGLAS, 99 John Street, New York, N. Y.

J. A. HOLMES, Director, Bureau of Mines, Washington, D. C.

JAMES F. KEMP, Columbia University, New York, N. Y.

F. W. BRADLEY, San Francisco, Cal.

J. PARKE CHANNING, 42 Broadway, New York, N. Y.

SEELEY W. MUDD, 1001 Central Building, Los Angeles, Cal.

D. W. BRUNTON, Denver, Colo.

H. FOSTER BAIN, 420 Market Street, San Francisco, Cal.

T. A. RICKARD, London, England.

B. B. LAWRENCE, 60 Wall Street, New York, N. Y.

Regulations for the Committee on Publication.

(*Adopted June* 16, 1911.)

1. The formation of a Publication Committee, consisting of the Secretary-Editor of the Institute, *Chairman*, and of at least twelve specialists, members of the Institute, who are willing to assist in passing on all papers offered for publication.

2. This committee shall perform its functions as follows:

(*a*) On the receipt of a paper by the Secretary, he shall send it to the member of this committee who, in his judgment, is most competent to pass upon it, accompanying the paper with his own opinion of its suitableness for publication, the history of the paper, and any other pertinent information.

(*b*) If the member of the committee and the Chairman agree upon the suitability or unsuitability of the paper, it shall be considered accepted for publication or rejected, as the case may be.

(*c*) If these two do not agree, the paper shall be submitted to a third, and the opinion of two of these three shall decide the matter.

(*d*) If a paper has been refused publication, the author may have the right of appeal, in which case the persons previously passing on the paper, together with others of the committee (appointed by the President) making five altogether, shall decide the question.

(*e*) If a paper has been accepted for publication, it shall be considered eligible to be placed on the program of a meeting.

3. The placing of a paper upon the program of a meeting does not give it the right to be published in the *Bulletin* or *Transactions* of the Institute; its suitability for publication must in every case be passed upon by the Publication Committee, as provided for in Section 2.

4. In case the Secretary is unable to secure a decision as to the suitability or unsuitability of a paper for publication, as directed in Section 2, before the time of announcing the program of a meeting, he may at his own discretion place the paper upon the program of the meeting, or refuse it a place thereon.

Affiliated Student Societies.

Any society of undergraduates at a technical school, comprising students in any branch of engineering, metallurgy, chemistry, geology, etc., may be recognized by the Council in its discretion as an Affiliated Student Society. A circular giving details of the plan of affiliation may be obtained on application to the office of the Secretary of the Institute.

The following societies have been placed by authority of the Council on the above list:

AFFILIATED STUDENT SOCIETIES.

The Mining Society of the Sheffield Scientific School, Yale University, New Haven, Conn. *President*, Karl C. Stadtmiller; *Secretary*, S. B. Gordy.

The University of Illinois Student Branch of the American Institute of Mining Engineers, Champaign, Ill. *President*, Leonard V. Newton; *Secretary*, L. W. Swett.

The Engineering Society of the University of Nevada, Reno, Nev. *President*, D. E. Bruce; *Secretary*, R. M. Seaton.

The University of Wisconsin Mining Club, Madison, Wis. *President*, H. E. Schmidt; *Secretary*, W. V. Bickelhaupt.

The Mining and Geological Society of Lehigh University, South Bethlehem, Pa. *President*, William E. Fairhurst; *Secretary*, Carl W. Mitman.

The School of Mines Society of the University of Minnesota, Minneapolis, Minn. *President*, Emory P. Baker.

The Mining Engineering Society of the Massachusetts Institute of Technology. *President*, L. B. Duke; *Secretary*, Lionel H. Lehmaier.

The Student Auxiliary Society of the American Institute of Mining Engineers of the University of Kansas, Lawrence, Kan. *President*, A. H. Mangelsdorf; *Secretary*, C. J. Hainbach.

The Associated Miners of the University of Idaho, Moscow, Idaho. *President*, James W. Gwinn; *Secretary*, J. Wallace Strohecker.

The State College of Washington Mining and Geological Society, Pullman, Wash. *President*, H. E. Doelle; *Secretary*, B. R. Kinney.

The Tejas Technical Society, School of Mines, University of Texas. *President*, G. C. Cartwright; *Secretary*, David S. Alley.

The Ohio State University Student Branch of the American Institute of Mining Engineers, Columbus, Ohio. *President*, Hugh B. Lee; *Secretary*, E. P. Elliott.

The Stanford Geology and Mining Society, Stanford University, Cal. *President*, B. E. Parsons; *Secretary*, E. D. Nolan.

The Senior Mining Society of Columbia University, New York, N. Y. *President*, Roger L. Strobel; *Secretary*, Clark G. Mitchell.

Mining Association of the University of California, Berkeley, Cal. *President*, Frank L. Wilson; *Secretary*, Stanley L. Arnot.

Tufts College Chemical Society, Tufts College, Mass. *President*, P. G. Savage; *Secretary*, W. S. Frost.

University of Washington Mining Society, Seattle, Wash. *President*, Horace H. Crary; *Secretary*, Clinton R. Lewis.

Student Branch of the American Institute of Mining Engineers, Iowa State College, Ames, Iowa. *President*, M. B. Hadley; *Secretary*, R. L. Hurst.

Missouri Mining Association of the Missouri School of Mines, Rolla, Mo. *President*, D. L. Forrester; *Secretary*, J. S. Irwin.

The Pick and Shovel Club of the Case School of Applied Science, Cleveland, Ohio. *President*, L. B. Riddle; *Secretary*, S. C. Stillwagon.

Colorado School of Mines Scientific Society, Golden, Colo. *President*, Alan Kissock; *Secretary*, George Wilfley.

Hydrographic Chart.

Owing to the great value to hydrographers of the chart contained in the paper, A Graphic Solution of Kutter's Formula, by L. I. Hewes and Joseph W. Roe (*Bulletin No.* 29, May, 1909, p. 454), a special edition for office or field use has been printed on durable cloth. Copies of this separate chart may be obtained, at a cost of 50 cents each, on application to the office of the Secretary of the Institute.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
AMERICAN INSTITUTE OF MINING ENGINEERS.
UNITED ENGINEERING SOCIETY.

WILLIAM P. CUTTER, Librarian.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

The Library contains about 42,000 volumes, including sets of technical periodicals and the publications of scientific and technical societies.

The members of the Institute, with few exceptions, are by the very nature of their profession forced to spend a large portion of their time in localities isolated from sources of information. To such members the Library can render valuable service through correspondence, and letters requesting information will receive special attention. The Library is prepared to furnish references and copies of articles on mining and metallurgical subjects; to determine, if possible, the existence of mining-maps, and to furnish general information as to the geology and mineral resources of all countries as far as these resources are known and published.

It is hoped that the members of the Institute will avail themselves freely of this special service. The Library will welcome inquiries on engineering subjects, and furnish information as far as such information is to be obtained.

All communications should be made as definite as possible so that the information received may be what is desired and not include collateral matter which may not be of interest. In this way the time spent in searching for such collateral matter will be saved, and as a result the information will be sent more promptly and in more usable shape.

The members of the Institute can be of service to the Library by forwarding copies of mining-reports, maps privately issued, and similar material, which will be classified, indexed, and made available to other members.

Suggestions for additions to the Library, either by purchase or personal solicitation as gifts, will be welcomed. It is hoped that members while in the city will use the Library freely, and assurance is given that most careful service will be rendered to them.

Library Accessions.

Mar. 1 to Mar. 31, 1912.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

AMERICAN INSTITUTE OF MINING ENGINEERS. Transactions, Vol. 41, 1910. New York, 1911.

AMERICAN TELEPHONE & TELEGRAPH CO. Annual Report of the Directors to the Stockholders, 1911. New York, 1912. (Gift of American Telephone & Telegraph Co.)

ANUARIO DE MINERIA METALURGIA É INDUSTRIAS QUIMICAS DE ESPAÑA, 1911. Madrid, 1911. (Purchase.)

LES APPLICATIONS DES ACIERS AU NICKEL AVEC UN APPENDICE SUR LA THÉORIE DES ACIERS AU NICKEL. By Ed. Guillaume. Paris, 1904. (Purchase.)

ART CLUB OF PHILADELPHIA. Charter, Constitution and By-Laws, 1912. N. p., 1912. (Gift of Art Club of Philadelphia.)

DIE ASPHALTMATERIALIEN, DEREN GEWINNUNG, ZUSAMMENSETZUNG, PRÜFUNG UND ANWENDUNG IM BAUWESEN. Wien, 1910. (Purchase.)

BASIC OPEN HEARTH STEEL PROCESS. By Carl Dichmann. Translated and Edited by A. Reynolds. New York, 1911. (Purchase.)

BEITRAG ZUM STUDIUM DER EISENCHROMLEGIERUNGEN UNTER BESONDERER BERÜCKSICHTIGUNG DER SÄUREBESTÄNDIGKEIT. Dissertation zur Erlangung der würde eines Doktor Ingenieurs. By P. Monnartz. Halle a/S., 1911. (Purchase.)

BRITISH COLUMBIA. BUREAU OF MINES. Preliminary Review and Estimate of Mineral Production for Year 1911. Victoria, 1912. (Exchange.)

CANADA. MINES DEPARTMENT. Report of the Commission Appointed to Investigate Turtle Mountain, Frank, Alberta, 1911. (Memoir No. 27.) Ottawa, 1912. (Exchange.)

CENTURY DICTIONARY AND CYCLOPEDIA. Vols. 1–12. New York, Century Co., 1911. (Purchase.)

CHRONOLOGY OF ANTHRACITE COAL. By Wm. Griffith. Scranton, n. d. (Reprinted from the Scranton *Truth*, Feb. 24, 1908.) (Gift of Author.)

CODES MINIERS RECUEIL DES LOIS RELATIVES A L'INDUSTRIE DES MINES DANS LES DIVERS PAYS PUBLIÉS SOUS LES AUSPICES DU COMITÉ CENTRAL DES HOUILLÈRES DE FRANCE. Espagne. By A. Stévenin. Paris, 1911. (Purchase.)

——— Etats-Unis du Mexique. Paris, 1911. (Purchase.)

——— Prusse et Alsace-Lorraine. By E. Langrogne. Paris, 1911. (Purchase.)

CONNECTICUT. GEOLOGICAL AND NATURAL HISTORY SURVEY. Bulletin No. 18. Hartford, 1911. (Exchange.)

DE BEERS CONSOLIDATED MINES, LTD. Annual Report, 23d, 1911. Kimberley, 1911. (Gift of A. F. Williams.)

DEPRECIATION OF FACTORIES. Mines and Industrial Undertakings and Their Valuation. Ed. 4. By Ewing Matheson. London, 1910. (Purchase.)

DICTIONNAIRE ABRÉGÉ DE SIX LANGUES SLAVES. By F. Miklosich. St. Petersbourg-Moscou, 1885. (Purchase.)

ENGINEERING AND MINING JOURNAL. Vol. 43, Nos. 15–26; Vol. 44, Nos. 1–15; Vol. 49, Nos. 13–26; Vols. 50–53; Vol. 54, Nos. 1–16, 18, 20, 22–27; Vol. 55, Nos. 2–24; Vol. 56, Nos 3–27; Vol. 57, Nos. 1–5, 7–13; Vol. 71, No. 8; Vol. 72, Nos. 12, 17–21; Vol. 73, Nos. 2, 14, 18, 25; Vol. 74, No. 6; Vol. 78, No. 3; Vol. 80, No. 20. New York, 1887, 1890–1894, 1901–1902, 1904–1905. (Gift of Otto F. Pfordte.)

ENGINEERS' SOCIETY OF PENNSYLVANIA. Directory, 1912. Harrisburg, 1912. (Exchange.)

FORTSCHRITTE DER PRAKTISCHE GEOLOGIE, Vol. 2, 1903–1909. By Max Krahmann. Berlin, 1910. (Purchase.)

GEOLOGIC RECONNAISSANCE OF THE ILIAMNA REGION, ALASKA. (Bulletin No. 485, U. S. Geological Survey.) Washington, 1912. (Exchange.)

GEOLOGY AND COAL FIELDS OF THE LOWER MATANUSKA VALLEY, ALASKA. (Bulletin No. 500, U. S. Geological Survey.) Washington, 1912. (Exchange.)

HANDBOOK FOR MINING INVESTORS. 1905-1910. Denver, 1905–1910. (Purchase.)

INTERNATIONALER KONGRESS FÜR BERGBAU, HÜTTENWESEN. Düsseldorf, 1910. (2 vols.) Düsseldorf, 1910. (Purchase.)

DER KUPFERBERGBAU IN DEN VEREINIGTEN STAATEN. By H. Fraenkel. Tübingen, 1911. (Purchase.)

LA MÉTALLURGIE A L'EXPOSITION UNIVERSELLE ET INTERNATIONALE DE BRUXELLES DE 1910. By Pierre Breuil. Paris, 1911. (Purchase.)

DIE METALLURGIE DES ZINNS MIT SPEZIELLER BERÜCKSICHTIGUNG DER ELEKTROMETALLURGIE. By Hans Mennicke. Halle a/S., 1910. (Purchase.)

MILWAUKEE SMOKE INSPECTOR. Annual Report, 1911. Milwaukee, 1911. (Gift of Milwaukee Smoke Inspector.)

MINERAL PRODUCTION OF THE PROVINCE OF QUEBEC, PRELIMINARY STATEMENT, DURING THE YEAR 1911. Quebec, 1912. (Gift of Quebec Department of Colonization, Mines and Fisheries.)

MINING INDUSTRY IN NORTH CAROLINA DURING 1908, 1909 AND 1910. (Economic Paper No. 23, North Carolina Geological and Economic Survey.) Raleigh, 1911. (Exchange.)

NEW MADRID EARTHQUAKE. (Bulletin No. 494, U. S. Geological Survey.) By M. L. Fuller. Washington, 1912. (Exchange.)

NEW ZEALAND. MINISTER OF MINES: Papers and Reports Relating to Minerals and Mining, 1911. Wellington, 1911. (Exchange.)

NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY. Bulletin Nos. 20, 23. Raleigh, 1911. (Exchange.)

——— Economic Paper No. 23. Raleigh, 1911. (Exchange.)

ONTARIO. BUREAU OF MINES. Report on the Mining Accidents in Ontario in 1911. (Bulletin No. 9.) Toronto, 1912.

——— Mineral Production of Ontario. (Bulletin No. 8.) Toronto, 1912. (Gift of Ontario Department of Mines.)

PHELPS, DODGE & CO. Annual Report, 1911. New York, 1911. (Gift of Phelps, Dodge & Co.)

PHÉNOMÈNES SPÉCIAUX ACCOMPAGNANT LA RUPTURE DES FILAMENTS INCANDESCENTS DES LAMPES ELECTRIQUES DANS LES MÉLANGES D'AIR ET DE GAZ COMBUSTIBLES. By H. Couriot and J. Meunier. Paris, 1912. (Gift.)

PRELIMINARY REPORT ON THE MINERAL PRODUCTION OF CANADA, 1911. Ottawa, 1912. (Exchange.)

RESULTS OF TRIANGULATION AND PRIMARY TRAVERSE FOR THE YEARS 1909 AND 1910. (Bulletin No. 496, U. S. Geological Survey.) Washington, 1912. (Exchange.)

SOCIÉTÉ CHIMIQUE DE FRANCE. Liste des Membres, 1912. Paris, 1912. (Exchange.)

SOUTHERN INDUSTRIES. The Tradesman Classified Directory and Buyers' Guide, 1910. Chattanooga, 1910. (Gift of R. W. Raymond.)

SURFACE GEOLOGY OF THE NORTHERN PENINSULA OF MICHIGAN. (Publication 7, Geological Series 5, Michigan Geological and Biological Survey.) Lansing, 1911. (Exchange).

TASMANIA. SECRETARY FOR MINES. Report, 1910. Tasmania, 1911. (Exchange.)

TIMBERING OF MINES, PARTICULARLY WITH STEEL. By R. B. Woodworth. (Paper read before the Kentucky Mining Institute, Dec. 11, 1911.) N. p., n. d. (Gift of Author.)

U. S. COAST AND GEODETIC SURVEY. Results of Observations made at the Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Maryland, 1909 and 1910. Washington, 1912. (Exchange.)

U. S. COMMISSIONER OF CORPORATIONS. Report on the Steel Industry. Part II. —Cost of Production, Preliminary Report, Jan. 22, 1912. Washington, 1912. (Gift of Commissioner of Corporations.)

U. S. GEOLOGICAL SURVEY. Bulletin. Nos. 485, 494, 496, 500. Washington, 1912. (Exchange.)

——— Mineral Resources. Part 11.—Nonmetals, 1910. Washington, 1911. (Exchange.)

——— Folio Nos. 179, 180. Washington, 1912. (Exchange.)

U. S. INTERSTATE COMMERCE COMMISSION. Annual Report on the Statistics of Express Companies, 2d, 1910. Washington, 1911. (Gift of Interstate Commerce Commission.)

——— Annual Report on the Statistics of Railways in the United States, 23d, 1910. Washington, 1912. (Gift of Interstate Commerce Commission.)

UNIVERSITY OF ARIZONA. Register, 1911–1912. Tucson, 1912. (Gift of University of Arizona.)

UNIVERSITY OF WISCONSIN. Engineering Series. Bulletin. Vol. 4, No. 6; Vol. 5, No. 6; Vol. 6, Nos. 1–2, 4–7; Vol. 7, No. 1. Madison, 1908, 1909, 1911. (Exchange.)

——— Science Series. Bulletin. Vol. 3, Nos. 5–10; Vol. 4, Nos. 1–4. Madison, 1906–1911. (Exchange.)

——— University Extension Series. Bulletin. Vol. 1, Nos. 2, 4. Madison, 1909, 1911. (Exchange.)

DIE UNTERSUCHUNG UND BEWERTUNG VON ERZLAGERSTÄTTEN. Ed. 2. By P. Krusch. Stuttgart, 1911. (Purchase.)

WALKER'S LOOSE LEAF POCKET BOOK FOR ENGINEERS. By N. R. Corke. London, n. d. (Purchase.)

WASHINGTON GEOLOGICAL SURVEY. Bulletin No. 7. Olympia, 1912. (Exchange.)

WASHINGTON UNIVERSITY, ST. LOUIS. 55th Annual Catalogue. St. Louis, 1911. (Exchange.)

WATER POWERS OF CANADA. By L. G. Denis and A. V. White. Ottawa, 1911. (Exchange.)

WATER POWERS OF NORTH CAROLINA. (Bulletin No. 20, North Carolina Geological and Economic Survey.) Raleigh, 1911. (Exchange.)

WEST VIRGINIA GEOLOGICAL SURVEY. Report on Jackson, Mason and Putnam Counties, with Maps, 1911. Wheeling, 1911. (Exchange.)

WESTERN AUSTRALIA. Topographical Map of Meekatharra. 1911. (Exchange.)

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY. Economic Series, No. 14. Bulletin No. 23. Madison, 1911. (Exchange.)

——— Soil Series, No. 1. Bulletin No. 24. Madison, 1911. (Exchange.)

GIFT OF HILL PUBLISHING CO.

BILLITER, JEAN. DIE ELEKTROCHEMISCHE VERFAHREN DER CHEMISCHEN GROSS-INDUSTRIE. I. Band. Halle a/S., 1909.

BOLETIN DE LA SOCIEDAD DE FOMENTO FABRIL. Oct.–Nov., 1911. N. p., 1911.

DE BEERS CONSOLIDATED MINES, LTD. Annual Report, 22d. 1910. Kimberley, 1910.

FINLAND. COMMISSION GÉOLOGIQUE DE FINLANDE. Bulletin No. 24–30. Helsingfors, 1910–1911.

——— ——— Geotekniska Meddelanden. Nos. 1–9. Helsingfors, 1906–1911.

GOLDFIELD CONSOLIDATED MINES CO. Annual Report, 5th, 1911. Goldfield, 1911.

GREECE. MINISTERS DES FINANCES. Bulletin Trimestriel du Commerce Special de la Grèce. No. 1, prémier trimestre, 1911. Athenes, 1911.

ITALY. MINISTERO DELLE FINANZE. Statistics del Commercio Speciale, Oct., 1911. Roma, 1911.

MEXICO. SECRETARIA DE ESTADO Y DEL DESPACHO DE HACIENDA. Boletin de Estadistica Fiscal, April, 1911. Mexico, 1911.

MINING JOURNAL (RUSSIAN), August–Oct., 1911. N. p., 1911.

MOUNT LYELL MINING & RAILWAY CO., LTD. Reports and Statements of Account, Sept. 30, 1911. Melbourne, 1911.

OM SVERIGES GRUNDVATTENFÖRDHALLANDEN. By J. J. Sederholm. N. p., n. d.

U. S. COMMISSIONER OF LABOR. Annual Report, 25th, 1910. Washington, 1911.

U. S. DEPARTMENT OF COMMERCE AND LABOR. Bureau of Statistics. Statistical Abstract, 1906. Washington, 1907.

WADDELL AND HARRINGTON. Addresses to Engineering Students. Kansas City, 1911.

ZUID AFRIKAANSE SPOORWEGEN EN HAVENS. Verslag van do Algemene Bestuurder van Spoorwegen en Havens. Dec. 31, 1910. Pretoria, 1911.

Maps.

MAP OF MINING CLAIMS, BUTTE AND VICINITY, MONTANA. 1907.

MAP OF THE MAIN SECTION, GLOBE MINING-DISTRICT, GILA CO., ARIZONA.

MAP OF THE NATIONAL RAILWAYS OF MEXICO.

MAP OF THE TONOPAH MINING-DISTRICT OF NEVADA.

MAP OF CALIFORNIA, Showing the Approximate Location of the Principal Mineral Deposits.

MAP OF MARQUETTE COUNTY, MICHIGAN. 1903.

MAP OF THE EMPIRE MINE.

CŒUR D'ALÈNE MINING-DISTRICT, IDAHO. (Blue-print.)

ATLANTIC MINE, HOUGHTON COUNTY, MICHIGAN, SECTION OF.

MINING AND AGRICULTURAL DISTRICT OF WESTERN ARIZONA AND SOUTHEASTERN CALIFORNIA.

LONDON-ARIZONA COPPER CO. Plan of the Mining Property.

——— Plan of the Smelter Site.

CAPITAL COAL CO. Surface Arrangement. 1911.

——— Longitudinal View of Tipple.

——— End Elevation of Wagon Bin.

TRADE CATALOGUES.

ELECTRIC AMALGAMATOR CO., Oakland, Cal. Electro-chemical amalgamation process. 10 pages.

CHICAGO PNEUMATIC TOOL CO., Chicago, Ill. Rockford magnetic cars. 3 pages.

CINCH EXPANSION BOLT CO., New York, N. Y. Expansion-bolts for anchorage. 24 pages.

RUGGLES MACHINE CO., Poultney, Vt. Aerial carrier and latest improved mill and quarry equipments. 30 pages.

JOHN A. ROEBLING'S SONS CO., Trenton, N. J. Wire rope and wire rope fastenings. 184 pages.

STURTEVANT MILL CO., Boston, Mass. Sturtevant ring roll mill. 8 pages.

WEBSTER MANUFACTURING CO., Tiffin, Ohio. Webster Method, Jan., 1912. Published in the interests of the company, and containing articles on "Handling Anthracite at Duluth Dock" and "Four Rope Drives and a Jackshaft." 24 pages.

United Engineering Society Library.

CHICAGO BUREAU OF PUBLIC EFFICIENCY. Water Works System of the City of Chicago, Dec., 1911. Chicago, 1911. (Gift of Chicago Bureau of Public Efficiency.)

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS. Proceedings of Annual Convention, 39th, 1911. Roanoke, 1911. (Gift of International Association of Fire Engineers.)

LAKE MICHIGAN WATER COMMISSION. Second Report. Urbana, 1911. (Gift of Lake Michigan Water Commission.)

LECTURE NOTES ON SOME OF THE BUSINESS FEATURES OF ENGINEERING PRACTICE. By Alex. C. Humphreys. Hoboken, 1912. (Gift of Stevens Institute of Technology.)

LIEBER'S INTERNATIONAL DIRECTORY. Jan., 1912. New York, 1912. (Gift of Lieber Code Co.)

MAP OF CENTRAL ASIA SHOWING EXTENSIONS OF TRANSCASPIAN RAILWAY, EAST OF TASHKENT. (With Mss. Notes.) (Gift of L. Goldmerstein.)

MILWAUKEE SEWERAGE COMMISSION. Summary of the Report of, 1911. Milwaukee, 1911. (Gift of Sewerage Commission of Milwaukee.)

VIRGINIA. STATE HIGHWAY COMMISSIONER. Annual Report, 5th, 1911. Richmond, 1912. (Gift of State Highway Commissioner.)

GIFT OF AMERICAN ELECTRIC RAILWAY ASSOCIATION.

CONNECTICUT. RAILROAD COMMISSIONERS. Annual Report, 56th–57th, 1908–1909. Hartford, 1909–1910.

MAINE. RAILROAD COMMISSIONERS. Annual Report, 48th, 1906. Augusta, 1906.

MASSACHUSETTS. RAILROAD COMMISSIONERS. Annual Report, 40th. Boston, 1909.

NEW HAMPSHIRE. RAILROAD COMMISSIONERS. Annual Report, 61st. Concord, 1905.

NEW YORK (STATE) RAILROAD COMMISSIONERS. General Railroad Laws. Vol. 3, 1906. Albany, 1907.

RHODE ISLAND. RAILROAD COMMISSIONERS. Annual Report, 1907–1908. Providence, 1908–1909.

MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of March, 1912.

Members.

BAXTER, CHARLES H............................Supt., Lovetto Iron Co., Lovetto, Mich.
BEDFORD, ROBERT H., Min. Engr.............North Star Mines, Grass Valley, Cal.
BENT, QUINCY...............Asst. to Prest., Maryland Steel Co., Sparrow's Point, Md.
BONNYMAN, JAMES, Prest., Bonnyman Norman C. & I. Co.,
907 Brown-Marx Bldg., Birmingham, Ala.
CLAPP, LAWRENCE R., Min. Engr................Silver Lake Mines, Silverton, Colo.
DAVIS, WALTER W., Vice-Prest. and Genl. Mgr., Yak Min., Mill. & Tunnel Co.,
Leadville, Colo.
FRÉCHETTE, HOWELLS, Min. Engr., Mines Branch, Dept. of Mines,
Ottawa, Ont., Canada.
FURNISS, THOMAS A...........................State Mine Inspector, Punxsutawney, Pa.
GERHARDT, REGINALD B., Mech. Engr.........................Felton, Oriente, Cuba.
GIBBS, GEORGE H., Steel Wks. Engr. and Mgr., Glany Mor, Baglan,
Briton Ferry, So. Wales, G. B.
HAMILTON, JOHN W. H., Cons. Engr..............29 Broadway, New York, N. Y.
JONES, ARCHIE H..........................Supt., Belmont Milling Co., Tonopah, Nev.
McKAY, RICHARD V.........Supt., Blast Furnaces, Penna. Steel Co., Steelton, Pa.
McKINNIS, CHARLES, Mining...Wallace, Idaho.
MACCARTHY, MARION S., Genl. Mgr., Manhattan Exploration Co.,
Alamos, Son., Mexico.
ORR, JOHN F., Eastern Mgr., Chalmers & Williams, Inc.,
149 Broadway, New York, N. Y.
PATTERSON, SEELY B., JR., Min. Engr...............P. O. Box 713, Douglas, Ariz.
RIO, JOSE P., Chief Engr., Irrigation & Water Supply of Brazil,
Bahia, Brazil, So. Am.
SALAS, LUIS E., Anal. Chem........................1922 Daly Ave., New York, N. Y.
SIEBENTHAL, CLAUDE E., Geol...............U. S. Geol. Survey, Washington, D. C.
SLOSSON, HENRY L., JR., Min. Engr...........265 Russ Bldg., San Francisco, Cal.
STAKEL, CHARLES J., Min. Engr.....Cleveland Cliffs Iron Co., Ishpeming, Mich.
STROHECKER, JOHN W., Min. Engr...........................Rossland, B. C., Canada.
VAN VALKENBURG, RALPH D., Mgr., Colonial Steel Co., 620 N. State St.,
Chicago, Ill.
WAKBER, GUSTAVUS R., Anal. Chem....................................Iron River, Mich.
WHEELWRIGHT, ORVILLE W., Geol......................................Florence, Wis.
WHITING, LOWE, Supt. of Mines...Iron River, Mich.
WILSON, JOHN BYRON, Min. Engr.......................................Wallace, Idaho.
WOLF, OTTO C., Engr. and Architect, 511 Dunckla Bldg.,
11th and Market Sts., Philadelphia, Pa.

CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the month of March, 1912. This list, together with the list published in *Bulletin* No. 63, March, 1911, and the foregoing list of new members, therefore, supplements the annual list of members corrected to Feb. 1, 1912, and brings it up to the date of Apr. 1, 1912.

ASHLEY, GEORGE H......................U. S. Geological Survey, Washington, D. C.
BATES, MOWRY..........Hughes Porcupine Mines, Ltd., Porcupine, Ont., Canada.
BENTLEY, THOMAS H., Min. and Civ. Engr., 603 Blake-McFall Bldg., Portland, Ore.
BROOKS, JOHN MCM., JR., Apartado 25, Jesus Maria, Guanajuato, Gto., Mexico.
BROWN, GILMOUR E., Care J. Snodgrass, 3a Finlayson Green, Singapore, Straits Settlements.
BROWN, WILLIAM N., Min. Engr., Brown & Clarkson, 812 Southern Bldg., Washington, D. C.
BRYDEN, CHARLES L..................................1015 Myrtle St., Scranton, Pa.
BURCH, H. KENYON.............................503 Union Oil Bldg., Los Angeles, Cal.
COLE, FRANK L..P. O. Box 475, Manila, P. I.
COLLIER, JOHN H., Min. Engr..........................1228 E. 37th St., Oakland, Cal.
COLLINS, GLENVILLE A., Cons. Engr., Prest., Anaconda Gold Mining & Reduction Co., 212 Columbia Bldg., Spokane, Wash.
COMSTOCK, THEODORE B...........................827 Beacon St., Los Angeles, Cal.
CORBIN, J. ROSS, Cons. Engr...........................421 Boston Bldg., Denver, Colo.
CRANSTON, ROBERT E...........701 First National Bank Bldg., San Francisco, Cal.
CROWELL, BENEDICT, Min. Engr., Crowell & Murray, 407 Perry-Payne Bldg., Cleveland, Ohio.
DAGGETT, ELLSWORTH.............................Cumings Apts., Salt Lake City, Utah.
DAVIS, CHARLES H..18 Old Slip, New York, N. Y.
DEMOND, CHARLES D.....................................704 Main St., Anaconda, Mont.
DOBLE, WILLIAM A., Chief Engr., Pelton Water Wheel Co., 19th and Harrison Sts., San Francisco, Cal.
DONNELLY, THOMAS F...........................P. O. Box 82, Sudbury, Ont., Canada.
DRAKE, FRANCIS.......................P. O. Box 249, Bulawayo, Rhodesia, So. Africa.
DRAPER, FRED W.......................Care Verk Isetz Corpn., Ekaterinburg, Russia.
EATHERLY, ADRIAN D............................521 Fatherland St., Nashville, Tenn.
EDELSTEEN, KARL J...Tromsoe, Norway.
EDWARDS, ROBERT L., Min. Engr...Ulysses, Idaho.
ELLIS, RALPH W.........................Care British Consulate, Mexico City, Mexico.
ELMER, WILLIAM W....................................614 Wilcox Bldg., Portland, Ore.
GILCHRIST, ARCHIBALD D., Royal Military College, Duntroon, N. S. W., Australia.
GRACE, WILLIAM F., Genl. Mgr., Waihi Grand Jc. Gold Co., Ltd., Waihi, Auckland, New Zealand.
GRAVE, ERNEST.................................2a Allende 20, San Luis Potosi, Mexico.
GRIPARI, GEORGE N. de..........................6 rue Cleopatre, Alexandria, Egypt.
HAAS, HERBERT..2217 Clinton Ave., Alameda, Cal.
HARRIS, ARTHUR L., Min. Engr......Apartado 12, Huauchinango, Pue., Mexico.
HERZIG, CHARLES S....................412 Salisbury House, London, E. C., England.
HOSKIN, ARTHUR J., Western Editor, *Mines and Minerals*, 1822 First National Bank Bldg., Denver, Colo.
HUNTOON, LOUIS D.......................................165 Broadway, New York, N. Y.
HUSTON, HARRY L., Atbasar Copper Fields, Fort No. 2, Seer Darinska Oblast, Turkestan Territory, Siberia.
INGERSOL, JOHN W..P. O. Box 504, Tonopah, Nev.
INOUYÉ, KOJI, Chief of Commercial Dept., Furukawa & Co., Marunouchi, Tokyo, Japan.
JARMAN, ARTHUR, Asst. Genl. Mgr., Waihi Grand Jc. Gold Co., Ltd., Waihi, Auckland, New Zealand.
KEADY, LYNN Y.....................926 Chamber of Commerce Bldg., Portland, Ore.
KIMBALL, EDWIN B.............1205 Alaska-Commercial Bldg., San Francisco, Cal.
LAIRD, GEORGE A., Cons. Engr., Mgr., Candelaria Mining Co., San Pedro, Chih., Mexico.
LAIRD, WILBUR G..............Care H. L. Doherty, 60 Wall St., New York, N. Y.
LEWIS, FRANCIS B., Genl. Mgr., Witwatersrand G. M. Co., Ltd., Box 1, Knights, Transvaal, So. Africa.
LOW, V. F. STANLEY, Care Natl. Bank of Australasia, Bishopsgate St., London, E. C., England.
LUDLOW, EDWIN............2d Vice-Prest., Lehigh Coal & Nav. Co., Lansford, Pa.
MCPHERSON, WILLIAM B..........................2301 W. 20th St., Los Angeles, Cal.
MANLEY, FRANK A.............................1121 Union Pacific Bldg., Omaha, Neb.
MASTERS, HARRIS K...Henderson, Ky.

MASTERS, JOHN E.............240 W. 5th St., Tucson, Ariz.
MATHER, THOMAS W.............Lewiston, Cal.
MESSLER, EUGENE L., Asst. to Prest., Riter-Conley Mfg. Co., 55 Water St., Pittsburg, Pa.
METGER, WILLIAM G.............54 E. Division St., Chicago, Ill.
MILLER, EMORY T.............414 W. St. Catherine St., Louisville, Ky.
MURPHY, FRANCIS J., Wks. Mgr., Great Cobar, Ltd., Cobar, N. S. W., Australia.
NEBEKER, AQUILA C.............Scranton Mines, Lehi, Utah.
NIGHMAN, CLARE E.............Kerr Lake Mining Co., Ltd., Cobalt, Ont., Can.
OPIE, NICHOLAS.............“The Pines,” Moonta, So. Australia.
OSGOOD, SAMUEL W.............Jefferson City, Tenn.
PARK, MUNGO.............Rawang, Selangor, Federated Malay States.
PARSONS, LEWIS A.............Dome Mines Co., Ltd., So. Porcupine, Ont., Canada.
POILLON, HOWARD A., Min. Engr., Poillon & Poirier, 25 Broad St., New York, N. Y.
POLKINGHORNE, JOHN, Inspector of Mines, P. O. Box 58, Cobar, N. S. W., Australia.
PORTER, JESSE C., Min. Engr......Aguacate Mines, San Mateo, Costa Rica, C. A.
PRENTIS, EDMUND A., JR., Ventanas Min. & Expl. Co., Ventanas, Dur., Mexico.
PRINCE, ERNEST, Student, Min. Engrg., Allis-Chalmers Co., P. O. Box 172, Chicago, Ill.
PRINGLE, ROBERT W., Care R. W. Jameson, The Club, Bulawayo, Rhodesia, So. Africa.
PRITCHARD, DE V. G.............P. O. Box 135, Cape Town, So. Africa.
RAGAZ, IVAN.............Andeer, Grison, Switzerland.
RAMBO, WILLIAM C. J.............923 First Natl. Bank Bldg., Denver, Colo.
RAY, FRANK A., Cons. Min. Engr.............6 Deshler Bldg., Columbus, Ohio.
RICHARDS, GEORGE M., Chief Min. Engr., Compagnie des Chemin de Fer du Congo Superieur aux Grand Lacs Africains, Kasindi, via Mombasa, Belgian Congo, Africa.
ROBINSON, SANFORD.............1477 Ridge Way, Los Angeles, Cal.
SALES, RENO H., Geol., Anaconda Copper Min. Co., 524 Hennessey Bldg., Butte, Mont.
SCHLERETH, C. QUINBY, Examining Engr., Penoles Exploration Co., Apartado 266, Mexico City, Mexico.
SCOTT, CYRUS E., Chief of Testing Dept., Consolidation Coal Co., Fairmont, W. Va.
SHALER, MILLARD K.............923 Ohio St., Lawrence, Kan.
SKELLEY, ROBERT D.............135 Orange St., Riverside, Cal.
SPURR, J. EDWARD.............Bullitt Bldg., Philadelphia, Pa.
STEWART, P. CHARTERIS A.............51 Redcliffe Sq., London, S. W., England.
STICKNEY, ALFRED W., Geol., Kyshtim Mining Wks., Ltd., Kyshtim, Govt. of Perm, Russia.
STOCKETT, ALFRED W......P. O. Box 5393, Johannesburg, Transvaal, So. Africa.
STOCKETT, LEWIS, Genl. Supt., Coal Mines, Canadian Pacific Ry., Calgara, Alta., Canada.
STOW, AUDLEY H., Cons. Civ. and Min. Engr.............Pocahontas, Va.
SWEETSER, ARTHUR L.............Leadville, Colo.
TAINTER, F. S.............55 Wall St., New York, N. Y.
THOMPSON, CAPT. C. HENRY.............1127 W. 27th St., Los Angeles, Cal.
TOM, ISIDORE, African & European Investment Co., Ltd., Box 2567, Johannesburg, Transvaal, So. Africa.
TRENGOVE, SAMUEL R., Supt. of Mines, Cons. Arizona Smelting Co., Mayer, Ariz.
TURNER, SCOTT.............Genl. Mgr., Arctic Coal Co., Tromso, Norway.
WARD, OSMER B., Care Broken Hill Prop. Block 10 Co., Broken Hill, N. S. W., Australia.
WESCOTT, WILLIAM P., Mng. Dir., Galena Signal Oil Co., Broadway Court, Broadway, Westminster, London, S. W., England.
WILKINSON, BERNARD A., Cia. Minera San Felipe de Jesus, Apartado 7, Real del Monte, Hid., Mexico.
WOAKES, ERNEST R.............6 Queen St. Pl., London, E. C., England.
WOLFLIN, HUGH M., Engr., U. S. Bureau of Mines, Mine Rescue Sta., University Campus, Seattle, Wash.
YUNG, MORRISON B., Min. Engr., Yale Club, 30 W. 44th St., New York, N. Y.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address of Record, from which Mail has been Returned.
Baxter, Francis K., Jr.,	423 Wells Fargo Bldg., San Francisco, Cal.
Cook, Edward H.,	Minas Birimoa, S. A , Birimoa, via Canelas, Dur., Mexico.
Danforth, A. H.,	Cotopaxi, Colo.
Fitzgerald, Thomas F. M.,	211 Sharon Bldg., Salt Lake City, Utah.
Furness, James W.,	Coffee, Trinity Co., Cal.
Geiger, Arthur W.,	Cortez, via Beowawe, Nev.
Goodloe, Meade,	So. Ariz. Smelting Co., Sasco, Ariz.
Hagemann, Wilhelm,	Metates, via Tepehuanes, Dur., Mexico.
Hollis, R. W.,	Silverton, Colo.
Johnson, Dion L.,	325 Water St., Pittsburg, Pa.
Lampshire, John O.,	Vulture Mine, Wickenburg, Ariz.
Leavell, John H.,	Buffalo Mine, Cobalt, Ont., Canada.
Le Noir, Frank H.,	Box 16, Mt. Bullion, Cal.
Levensaler, Lewis A.,	Cordova, Alaska.
McDougall, Wallace D.,	20 Bedford Place, Russell Sq., London, Eng.
Mills, Ronald Van A.,	Imperial Pei Yang University, Tientsin, China
Moore, Roy W.,	P. O. Box 48, Velasco, Tex.
Munroe, Martin,	Bengal Coal Co., Murulidih, Mohada, B. N. Ry., Bengal, India.
Nelson, D. W. C.,	Baker City, Ore.
Nobs, Frederick W.,	Negociacion Minera Santa Maria de Guadalupe y Anexas, S. A., Minillas, Zac., Mexico.
Pearson, William R.,	628 W. 114th St., New York, N. Y.
Perks, Harry B.,	419 Board of Trade Bldg., Portland, Ore.
Rathborne, Merwyn R. W.,	Amargosa, via Las Vegas, Nev.
Rhew, James W.,	Cia. Minera y Exploradora de Ventanas, S. A., Ventanas, Dur., Mex.
Sheldon, Waldo,	Urique, Chih., Mexico.
Short, Frank R.,	Carson City, Nev.
Thornton, Edward T.,	Apartado 30, Matehuala, S. L. P., Mexico.
Twynam, Henry,	O. K. Copper Mine, Cairns, No. Queensland, Australia.
Watson, Ralph W.,	Calloo, Utah, Clifton Mail box.
Weddle, Joseph H.,	100 William St., New York, N. Y.

NECROLOGY.

The deaths of the following members were reported to the Secretary's office during the month of March, 1912:

Date of Election.	Name.	Date of Decease
1890.	*Hofius, W. D.,	February 27, 1912.
1899.	*Snedaker, J. Angus,	—— ——, 1912.
1902.	*Wanless, George J.,	March 3, 1912.
1894.	*Young, John W.,	February 14, 1912.

* Member.

BIOGRAPHICAL NOTICE.

Thomas Guilford Smith was born Aug. 27, 1839, at Philadelphia, Pa., and after a preliminary education at the Central High School in that city, entered the Rensselaer Polytechnic Institute at Troy, N. Y., from which he received in 1861 the degree of Civil Engineer. Returning to Philadelphia, he sought a position under the Philadelphia & Reading Railroad Co., of which his uncle, Charles E. Smith, was President. Mr. Smith referred him to George B. Roberts, a Rensselaer graduate of 1852, who became ultimately President of the Pennsylvania R. R. Co., and who was in 1861 Chief Engineer of the Mahanoy & Broad Mountain R. R., afterwards a part of the Philadelphia & Reading system, but at that time in the stage of preliminary survey and initial construction. Mr. Roberts employed him at once in this work, and he remained in the service of the company until the location and construction of the line had been completed. When he left it, in 1865, he was Resident Engineer, with headquarters at Mahanoy Plane.

T. GUILFORD SMITH.

The history of this enterprise deserves special notice. At that time the Mahanoy Valley was reached by one railroad only—the Mine Hill & Schuylkill Haven—which delivered its coal at the latter point to the Philadelphia & Reading, charging lateral tolls deemed exorbitant by the coal-operators of the region. To remedy this situation, a liberal charter was obtained from the State for the Mahanoy & Broad Mountain line. After the opening of this line, its inroads upon the tonnage of the Schuylkill Haven road were so serious that the latter company was glad to sell out to the Reading, which assumed its bonded debt, and agreed to pay a certain annual dividend upon its stock.

After leaving the service of the railroad, Mr. Smith became Manager of the Philadelphia Sugar Refinery, a position which he retained from 1866 to 1869, when he resumed the practice of his profession as engineer. During the four years which followed, he traveled as far west as St. Louis, and as far south as Chattanooga, Mobile, and New Orleans, investigating natural resources and commercial conditions in the interest of sundry clients, such as the Allentown Iron Co., the Clyde Steamship Co., and the Philadelphia Sugar Refinery. It is interesting to note that, at this early date, the Clyde Steamship Co., which had been taking its coal via the Mississippi river from Pittsburg, tried to get a supply from the Warrior coal-field of Alabama; but, though Mr. Smith's investigation showed the quality of the Warrior coal to be satisfactory, he found the rates of transportation by the Mobile & Ohio R. R. from the mines to Mobile so high as to be prohibitory; and, since he was unable to get these rates reduced, his clients were forced to go on buying, at New Orleans, coal which had come all the way from Pittsburg, through the Ohio and Mississippi rivers—an amusing case of the "short haul vs. long haul" commercial problem.

During the same period Mr. Smith was connected with the development of the block-coal of Indiana, in which Gen. Pleasanton (Franklin B. Gowen's chief engineer) was interested; and in 1872 he went to Europe with Gen. Pleasanton, on the business of one of these enterprises.

Early in 1873 he was elected Secretary of the Union Iron Co., of Buffalo—a position which involved many administrative as well as merely clerical duties, and which he retained until 1878. In that year he formed, with J. J. Albright, the firm of Albright & Smith, which took charge of the tonnage passing northward from Williamsport to the Lake region; and in the same year he became the sales agent at Buffalo of the Philadelphia & Reading Coal & Iron Co. He retained this position until 1892, and, in 1889, added to it the agency of the Carnegie Steel Co. In 1892 he became Vice-President of the N. Y. Car-Wheel Works, the St. Thomas Car-Wheel Co., and the Canada Iron Furnace Co., in connection with which enterprises he gave considerable attention to the manufacture of charcoal-iron and of car-wheels. In following years he became Manager of Sales for sundry subsidiary companies of the U. S. Steel Corporation, including the Illinois Steel Co., the Carnegie Steel Co., the U. S. Steel Products Export Co., the Tennessee Coal, Iron & R. R. Co., etc.

In addition to his business trip in 1872, Mr. Smith visited Europe in 1901, and the Orient also in 1894, 1898, and 1907. In 1890 he was elected by the Legislature of New York a Regent of the University of the State—an office which he held until his death. Of the Pan-American Exposition, held at Buffalo in 1901, he was Chairman of the Fine Arts Committee.

Among the academic and honorary degrees conferred upon Mr. Smith are the following: From the Central High School of Philadelphia, A. B. (1858), M. A. *ad eundem* (1863); from Hobart College, honorary membership in the Phi Beta Kappa (1894), and the honorary degree of LL. D. (1899); from Alfred University, the same degree (1903). This honor was bestowed by Hobart College in consideration of his services as Regent of the University to the cause of education in the State, and by Alfred University in recognition

of his decisive influence in the establishment at that institution of the N. Y. State School of Ceramics.

He was a member of the Franklin Institute and the Academy of Sciences, of Philadelphia; the American Society of Civil Engineers; the American Academy of Political and Social Science; the American Economic Association; the Shakespeare Society of New York; the N. Y. State Historical Society; the Buffalo Fine Arts Academy (of which he was at one time President); the Sons of the Revolution; the Military Order of the Loyal Legion (hereditary member); the Society of Colonial Wars; the Pennsylvania Society; the Welcome Society of Pennsylvania: the Charity Organization Society of Buffalo; and for a time President of the Buffalo Public Library.

Mr. Smith became a member of this Institute in 1871, the year of its organization, and retained through life his loyal and sympathetic interest in it and in its work. His contributions to the *Transactions* comprise a paper on Gruson Rotating Turrets (*Trans.*, xxx., 291); Remarks on the paper of W. H. Morris, The Control of Silicon in Pig-Iron (*Trans.*, xxxi., 364); and Remarks on the paper of James Hall, A Geological Map of the State of New York (*Trans.*, xxxi., 572). But these contributions fall far short of representing the measure of his generous support of the Institute, as those members who attended the Buffalo meetings of 1888 and 1898 can testify. Alas! how few of them are left to bear witness! Let me speak for them all in praise of this accomplished, honorable, genial gentleman, master of both professional knowledge and business methods, efficient and unselfish public servant, true friend to his friends and true lover of his fellow-men!

Mr. Smith died Feb. 20, 1912, after several years of impaired health, endured with patience, courage, and dignity. R. W. R.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Notes on the Laramie Tunnel.

BY DAVID W. BRUNTON, DENVER, COLO.

(San Francisco Meeting, October, 1911.)

MINE-DRAINAGE and the ever-increasing demand for water on the plains have within the past few years necessitated the driving of a great number of adits and tunnels, including many of considerable size and great length. In most instances, existing conditions have called for extreme rapidity of execution; and this necessity, coupled with the high altitudes at which most of the work has been carried on, excessive freight-rates, and difficulty of access, has involved many complex and interesting problems.

One of the most rapidly executed undertakings of this class is the Laramie tunnel, recently completed for the Laramie-Poudre Reservoirs & Irrigation Co. This tunnel is driven through Green ridge, a spur of the Continental Divide, which separates the Laramie river from the Cache-la-Poudre in Laramie county, Colo. Green ridge is extremely persistent, and further northward in Wyoming is known as Sherman hill, the highest point on the Union Pacific railway. At the point where the tunnel is driven, two opposing bends bring these streams within 2.5 miles of each other, with a difference in elevation of 500 ft. The rock exposed on the banks of the two rivers does not differ materially in hardness; and, without a geological study of the conditions involved, it would appear that the difference in the depth of erosion of the two streams is due principally to the greater volume of water at this point in the Cache-la-Poudre, which has a drainage-area above the tunnel-portal of 110 sq. miles, as against 30 sq. miles of natural drainage for the Laramie. To increase the water-supply at the tunnel, however, this latter amount has been augmented by two side collection-canals, which bring the available drainage-area up to 84 square miles.

The nearest railroad shipping-point to the eastern portal is

Fort Collins, Colo., 40 miles to the east in an air-line; and some idea of the difficulties of access and transportation may be gathered from the fact that the wagon-road between the two points is 65 miles long, and the freight-rate $22 per ton. The western portal was reached from Laramie City, Wyo., over a very hilly wagon-road 74 miles long, on which the freight-rate varied from $20 to $25 per ton, according to the season and the condition of the road.

The tunnel was driven for the purpose of conveying through the divide 800 cu. ft. of water per second, which is to be diverted from the Laramie and discharged into the Cache-la-Poudre, where it will serve to augment the water-supply of the latter stream and enable it, for a time at least, to meet the demand for water in the immensely-rich irrigation-district which it serves.

Fig. 1 shows the profile of the tunnel, which was run on a 1.7-per cent. grade, with an elevation at the intake of 8,580 ft., and a length from portal to portal of 11,306 ft. The open-cut approach on the eastern end was 45 ft., and on the western approach 1,200 ft. long, making a total length of cutting on the floor-line of 12,551 feet.

Fig. 2 shows a cross-section of the tunnel, which, as shown, is 7 ft. 6 in. in height by 9 ft. 6 in. in width, although, to save time and expense in trimming, it was generally run 8 by 10 ft. The rock is very hard, tough granite; and this section was selected, instead of the ordinary form of tunnel, with a view to diminishing the cost and expediting the work of driving; since the expense of cutting out the corners to the usual rectangular form would have been very considerable. Moreover, should soft ground be encountered anywhere in the course of the tunnel, the arched form selected would add greatly to the strength of the opening.

Work on the power-plant for operating the tunnel was begun Dec. 1, 1909, and continued throughout the winter, although progress was greatly impeded by intense cold and heavy snowfall.

The hydro-electric power-plant was erected on the west bank of the Cache-la-Poudre, nearly opposite the eastern portal, and the intake of the pipe-line was located at an exceedingly good natural site nearly 2 miles farther up the stream. The dam

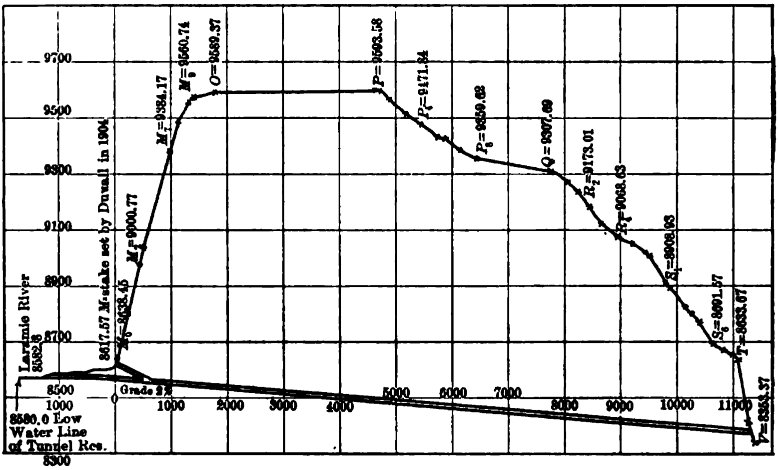


FIG. 1.—PROFILE OF THE LARAMIE RIVER TUNNEL.

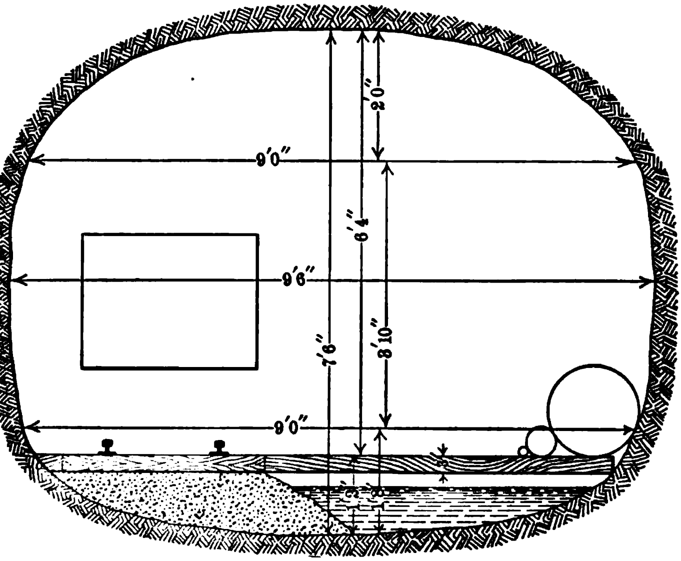


FIG. 2.—CROSS-SECTION OF THE LARAMIE RIVER TUNNEL, SHOWING POSITION OF TRACKS, DRAIN, VENTILATING, COMPRESSED-AIR AND WATER-PIPES.

was of the usual log-type, 10 ft. high, faced with two thicknesses of 2-in. plank, and fitted with suitable intake-screens, penstock, and gate. The water was conveyed from the dam to the power-plant through 8,500 ft. of 22-in. wooden pipe, bound together with round steel bands so as to stand the pressure-head at all points, with a factor of safety of 3.5. The bands were all dipped or painted with two coats of paint. The total head at the water-wheel was 268 ft. and the effective head 200 ft. Relief-valves were provided along the entire length of the pipe to prevent collapse in the case of sudden emptying. The foundations for the machinery, and the waste-ways from the water-wheels, were all of concrete. The power-plant consisted of:

One 48-in. Pelton double-nozzle wheel, developing, at 245 rev., 250 b.h-p., used for driving the generator. The governor was a special Pelton oil-governor of the piston-type, controlling Pelton stream-deflectors attached to the water-wheel nozzles.

One 48-in. Pelton single-nozzle water-wheel; capacity, 130 h-p. at 245 rev. The speed-control of this wheel, known as the Pelton special air-control mechanism, consists of a compressed-air cylinder with suitable connections to the nozzle-deflector. The flow of air to the cylinder is controlled by a pilot-valve with a safety counter-balance. This special air-control stops the operation of the water-wheel when the pressure in the air-receiver reaches the normal, and whenever the pressure drops 8 or 10 lb. it automatically starts the water-wheel; the function of the counter-balance being to stop the wheel in case of a rupture in the air-pipe or the tank. This device, while exceedingly simple, gave the utmost satisfaction and shut down the water-wheel whenever the demand for air stopped, thus greatly reducing the wear and tear on the compressor.

Electricity for power and light was supplied by a General Electric type A. T. B., 150-kw., 600-rev. per. min., 2,300-volt, A. C., 3-phase, 60-cycle generator.

Compressed air for the east portal was furnished by a belt-driven Ingersoll-Rand Imperial compressor, Type N., 17- and 10-in. cylinders, 14-in. stroke, located in the power-house; and air for the west portal was supplied by a duplicate compressor, electric-driven.

Ventilation in the heading from the eastern portal was fur-

nished by a Connersville special heavy-duty type of exhauster, belt-driven, having a displacement of 13 cu. ft. per rev. and a normal speed of 250 rev. per minute.

Ventilation in the heading from the western portal was provided by a duplicate exhauster, electric-driven; current for this purpose and for operating the air-compressor and electric hoist being carried over the mountain from the generating-station on the Cache-la-Poudre by a 3,300-volt power-line. Both exhausters were arranged with by-passes so that they could be used either for exhausting from the face or blowing air into it, as desired.

To operate the incline at the western portal, an electric hoist was installed which had a capacity of 5,000 lb., raised 120 ft. per min., the hoist being gear-connected to a General Electric 440-volt, 60-cycle, 3-phase, 25-h-p. motor, operated by a street-railway type controller and resistance.

The western, or intake, portal of the tunnel was necessarily near the level of the Laramie river channel; and as the bank immediately above it showed, by springs and seepage, the presence of a very considerable amount of water, it was deemed best to avoid tapping this water-bearing area by beginning work above it and running down to the grade of the tunnel with a 25-per cent. incline 188 ft. long through rock which promised to be nearly, if not quite, free from water.

Pending the completion of the power-plant, work was commenced with pneumatic drills, supplied with air from small steam-operated Norwalk compressors, at the eastern portal on Dec. 25, 1909, and on the incline at the west end of the tunnel on Jan. 16, 1910. At first Leyner No. 7 water-drills were used in both headings; but, although the rate of drilling was satisfactory, the repairs were high, and the desirability of a heavier and more sturdy drill became so apparent that Leyner designed and supplied to the contractor, in July, 1910, a very much improved and heavier drill, now catalogued and sold as Model No. 8.

In order to obtain, on the completion of the tunnel, as much salvage as possible from the sale of machinery and tools, everything purchased was of the very best quality, and, wherever possible, standard patterns and sizes were ordered. For this reason the tunnel-cars (shown in Figs. 3, 4, 5, and 6) were of

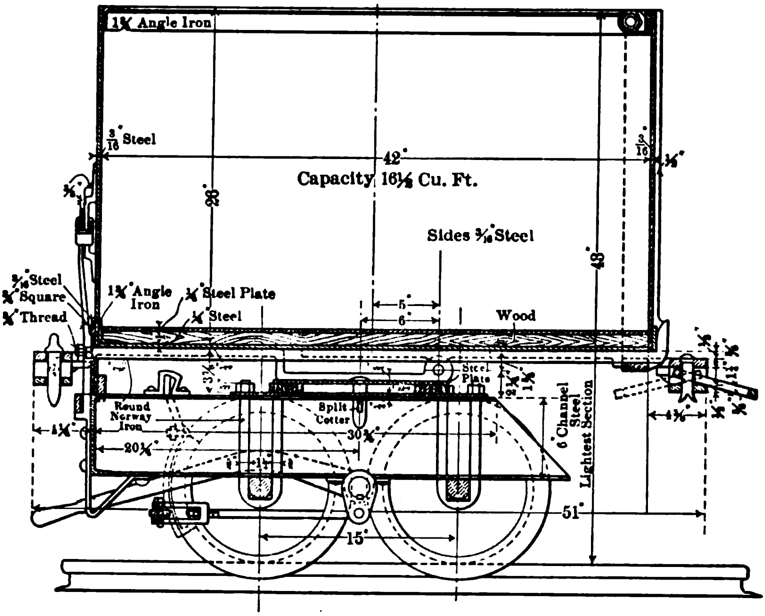


FIG. 3.—ELEVATION OF TUNNEL-CAR USED IN LARAMIE RIVER TUNNEL.

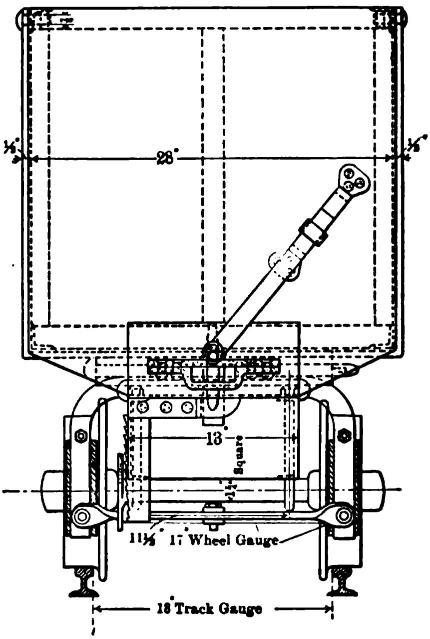


FIG. 4.—END-VIEW OF TUNNEL-CAR.

the standard mining type, fitted with brakes and equipped with turn-tables permitting either side- or end-dumping. The wheels were of the well-known Cowenhoven Tunnel pattern, with closed hub ends, as illustrated in Fig. 6, which also shows very clearly the brake-mechanism.

These wheels are lubricated by filling the hub recess with non-fluid oil, forced in from a "gun" through an opening closed by a 0.25-in. pipe-plug.

As the system of car-handling in the tunnel-headings necessitated throwing all of the cars over on their sides once, and nine-tenths of them twice, on each trip, the connections between the trucks and bodies of the cars were carefully planned

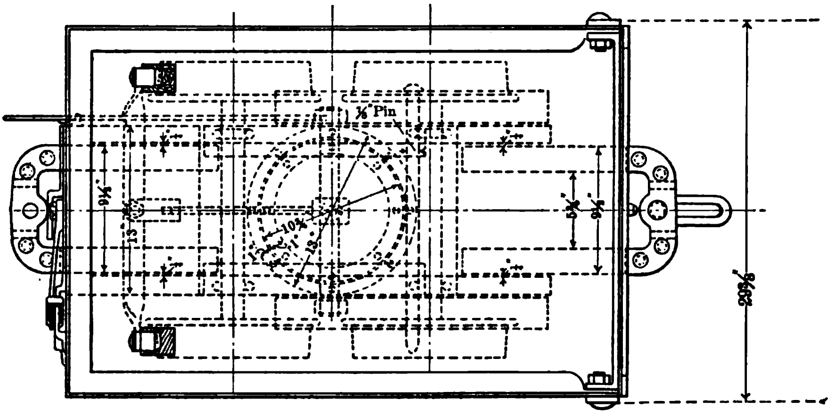


FIG. 5.—PLAN OF TUNNEL-CAR.

and made unusually strong. The turn-tables were fitted with two concentric rings, Figs. 3 and 5, and the locking-mechanism for securing the bodies to the trucks was so designed that when the releasing-lever was fastened in place the cars were as rigid as if the bodies were riveted to the axles.

Owing to the great length and number of drills used, they were hauled into the tunnel on special cars, Fig. 7, 10 ft. long, and provided with compartments to keep separate the different lengths of steel.

The trucks, couplings, bumpers, etc., were exact duplicates of those on the muck-cars, so that these tool-cars could be placed anywhere in the trains.

Hollow drill-steel 1⅛ in. in diameter, Bulldog brand, was

used; and the bits preferred were of the usual cruciform pattern.

To obtain and keep in such a high altitude, especially during the severe winter weather, the best class of men, it was necessary to build at both ends of the tunnel warm and comfortable quarters for the employees, as well as repair-shops, stores and hospitals. Commodious buildings were erected, and, instead of crowding the men into the usual bunk-houses, the houses were divided up into rooms like a hotel, not more than two men being assigned to one bed-room. Each of these rooming-houses contained a general sitting-room, a bath-room, and a wash-room. As a further inducement to obtain and retain the best class of workmen, the dining-rooms were very comfortably furnished and run on a most generous plan. The men were charged $1 per day for board, but, even at this rate, expenditures exceeded receipts by over $1,000 during the construction of the tunnel; all of which was more than compensated for by the class of men retained and the good feeling engendered by comfortable quarters, good living, and liberal treatment.

A store had to be maintained on each side of the mountain for the convenience of the employees; and, to prevent dissatisfaction from this cause, no article was sold at more than 10 per cent. profit. Liquor of any kind was not allowed in camp. Special care was taken to insure the safety of the employees, with the result that no one was killed and only one man very slightly injured during the whole progress of the work. Repair- and blacksmith-shops were erected at both ends of the tunnel, and, among other tools, each shop was supplied with a Leyner drill-sharpener.

The power-plant was completed and turned over to the contractor on Mar. 15, 1910, and was in continuous operation from that time until the completion of the tunnel, no repairs or shut-downs of any kind being necessary, except a few minutes stoppage at long intervals to tighten up driving-belts. The machinery was found to be entirely suitable and adequate to the service; and air-pressures of 120 lb. at the power-house were easily maintained when all the drills, blacksmith-forges, and sharpening-machines were in operation.

Ventilation was provided for by carrying a 16-in. air-pipe

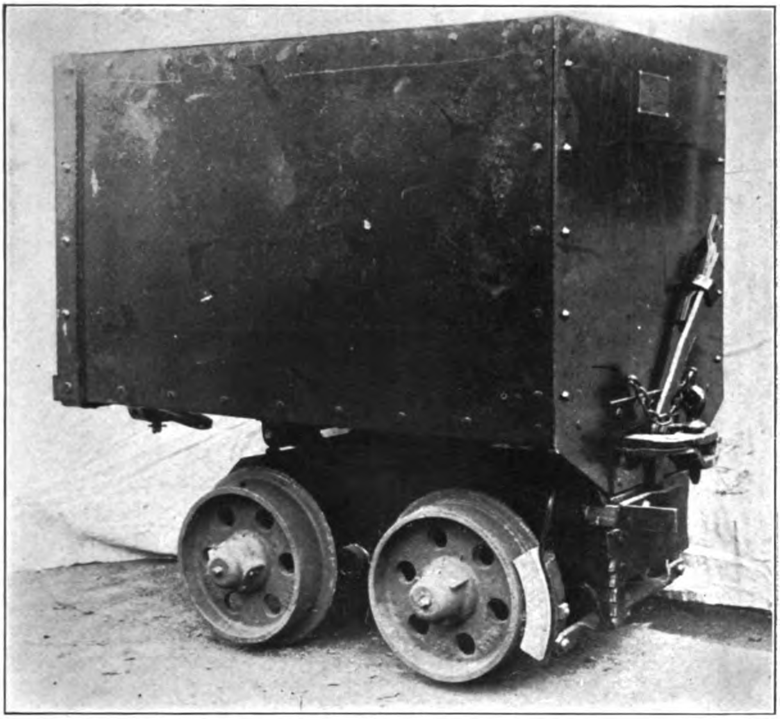


FIG. 6.—TUNNEL-CAR USED IN CONSTRUCTION OF LARAMIE RIVER TUNNEL.

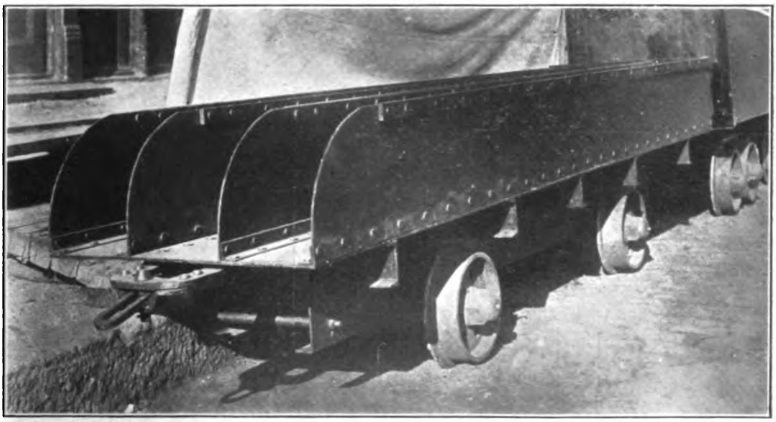
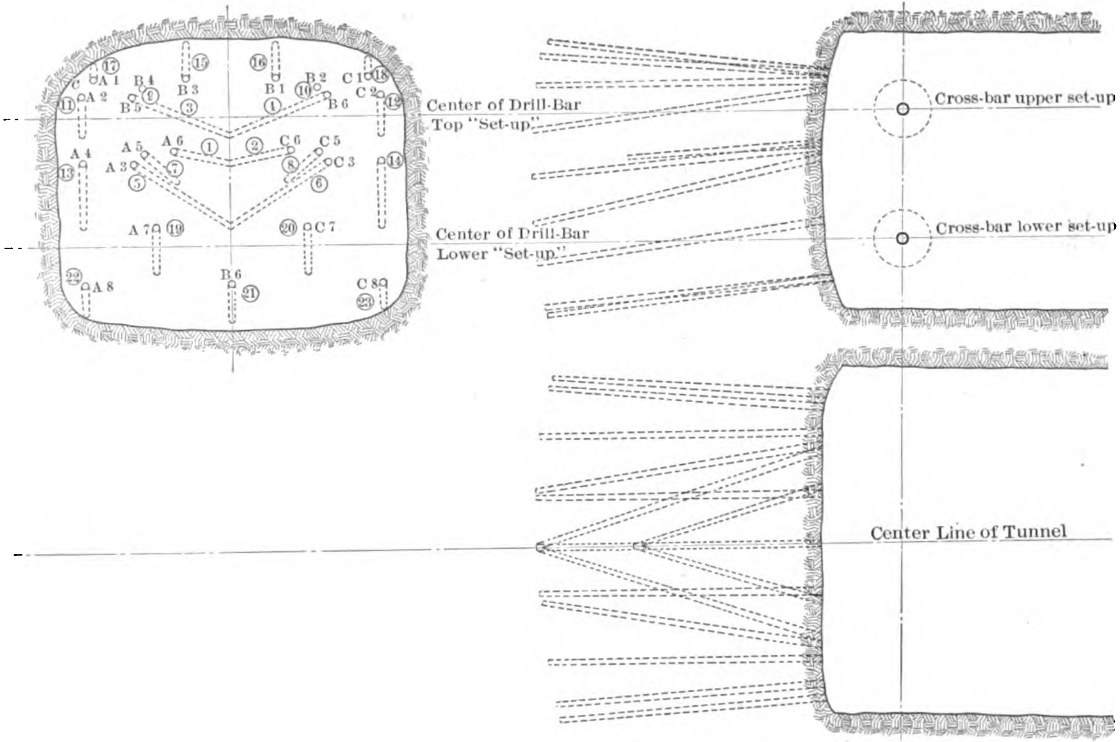


FIG. 7.—CAR FOR TRANSPORTING DRILLS, LARAMIE RIVER TUNNEL.



Cross-section shows position and order in which holes are drilled. Left-hand drill designated *A*; center, *B*; right, *C*. Figures in circles give order of firing.
Longitudinal section shows location of holes and position of cross-bar on upper and lower "set-ups."
Plan shows position and depth of holes. Cut holes are drilled to intersect to insure simultaneous explosions.

FIG. 8.—CROSS- AND LONGITUDINAL SECTIONS AND PLAN OF LARAMIE TUNNEL AT FACE.

to within 150 ft. of each face. This pipe was of No. 16 gauge sheet-steel, dipped in asphalt, and put together with the usual slip-joints, wrapped with tar-saturated canvas wherever an air-tight joint could not be made without it. Four-inch pipes were used for conveying air from the compressors into the tunnel, but for a few hundred feet from the face this size was reduced to 3- and 2-in., the smaller sizes being taken up and replaced by 4-in. as the tunnel advanced.

The water to supply the Leyner drills on the eastern heading was taken from a small stream above the tunnel and conveyed to the face by a 1-in. pipe. At the western end of the tunnel no provision of this kind was necessary, as the tunnel supplied not only the necessary water but, unfortunately, an over-abundant surplus.

In the early stages of the work numerous tests were made to determine the best and most economical explosive for use in the tunnel. The explosives tested varied in strength from blasting-gelatine, having the same strength as pure nitro-glycerine, to powders having only 50 per cent. of that strength. As the result of these experiments, it became clear that, except where the granite was extraordinarily hard and tough, Repauno 60-per cent. gelatine gave as good results as explosives of higher grade.

Insolid and Z. L. fuse, both of German manufacture, having a speed of about 1 ft. in 40 sec., were used, with 6x caps clamped to the fuse by a California "crimper." The fuse was cut to exactly 10-ft. lengths for all of the holes, except for the lifters, which were 2 ft. longer; the reason for the increased length of the lifter-fuse being that, since these holes could not be examined after the charge had been fired as readily as the holes in the face, it was desirable to have them explode some time after the other shots, so that the reports could be clearly heard and counted. Where the ground was wet, the fuse was tarred for 1 ft. back from the cap, the tar being worked in around the edges of the cap very carefully, and the remainder of the fuse to within 2 ft. of the end was thoroughly coated with heavy axle-grease. Where the heading was dry, the fuse was slit and ignited with candles; but where it was wet American fuse-lighters were used with excellent results.

European tunneling-methods were copied as closely as the American wage-scale and differences of conditions would permit. A workman once assigned to a position in the tunnel remained there, not being allowed to change even from one side to the other. He was not allowed to drop his tools at shift-change, but was obliged to hand them to his successor, and, in case of his successor's non-arrival, was expected to work another shift, care being taken, of course, that either a substitute was found or meals were sent in to the man working a double turn.

To give each man a personal interest in the work, what is known as the "bonus" system was maintained. At first, the following bonus was paid to each underground workman:

Distance Driven Per Month. Feet.	Per Day Extra.
From 400 to 425,	$0.25
From 425 to 450,	0.50
From 450 to 475,	0.75
From 475 to 500,	1.00
From 500 to 525,	1.25
From 525 to 550,	1.50
From 550 to 575,	1.75
From 575 to 600,	2.00

After a few months this schedule was discontinued, as it was found to be both cumbersome and excessively high, considering the rate of progress made possible by the superior equipment; and the following bonus-rate was adopted:

When the rate of driving for any calendar month exceeded 400 ft. and was less than 500 ft., each underground employee was paid $10 extra; between 500 and 600 ft., the bonus was $15; and between 600 and 700 ft., $20.

This bonus should have been paid to the men in currency, so as to distinguish it from the earnings under the wage schedule, but, as this was impracticable, money earned under the bonus was paid with a separate check, thus giving the men a better opportunity to realize what speed meant to them as well as to the contractor:

List of Employees and Wages Paid:

1	Superintendent,		$10.00 per day.
3	Foremen,	each	5.00 per day.
9	Drillers,	each	4 50 per day.
6	Helpers,	each	4.00 per day.
18	Muckers,	each	3.50 per day.
6	Drivers,	each	4.50 per day.
3	Dumpers,	each	3.50 per day.
1	Track- and pipe-man,		3.50 per day.
1	Master mechanic,		6.00 per day.
1	Stable-boss and janitor,		3.00 per day.
2	Power engineers,	each	110.00 per month.
1	Car-greaser,		3.00 per day.
1	Man at odd jobs,		3.00 per day.
1	Timberman,		4.00 per day.
1	Timberman's helper,		3.50 per day.
2	Blacksmiths,	each	5.00 per day.
2	Blacksmith's helpers,	each	3.50 per day.
1	Book- and time-keeper,		110.00 per month.

In the operations of setting up the machines, drilling, firing, and mucking, the utmost regularity and system were observed; and, while the time consumed in these different operations varied somewhat from day to day, there was a remarkable degree of uniformity in the amount of work performed by the different shifts.

Ventilation was accomplished by the exhaust-system entirely; and in from 10 to 12 min. after the last shot was fired the air at the face was clear enough for the men to begin work in safety and comfort. As a good illustration of the purity of the air, it may be mentioned that the engineers, in giving center-lines, were able to take back-sights through 6,500 ft. of tunnel.

Picking down the roof and squaring up places on the sides for the drill-bar rarely occupied more than 10 min. The adjustable end of the cross-bar was always placed on the right-hand side of the tunnel, the lifter on this corner having been exploded last for the purpose of clearing away the muck and leaving plenty of room for the men to operate jack-bars. The drillers and the foreman attended to this work while the helpers were busy bringing forward the hose, air-pipe, water-pipe, and steel. Even with the tremendously heavy charges fired, most of the broken rock lay within 30 ft. of the face and rarely exceeded 5 ft. in depth at any point; thus making it

quite easy to bring the bar, drills, etc., over the pile of muck, without waiting for it to be removed. Jacking the cross-bar into place seldom took more than from 6 to 8 min., and clamping the drills on the bar, attaching the hose, and starting them up consumed, according to conditions, anywhere from 5 to 15 minutes.

With the Leyner drills used there was, of course, no dust in the face, and the stream of mixed air and water passing through the hollow steel not only kept the bit cool, but removed the cuttings as fast as they were formed, thereby making it unnecessary to stop the drills and take out the steel for the purpose of cleaning out the holes. Unless the rock was unusually hard, each drill could be run down the full length of the step between the different sizes, which was usually maintained at 18 in. on the starters and 24 in. on the long drills, without any necessity for change.

The directions of the holes and the order in which they were drilled are shown in Fig. 8.

The time required to complete the 18 holes which were drilled from the top set-up ranged from 3 to 4.25 hr., the holes averaging about 7 ft. 6 in. in depth. The time required to lower the bar from the upper to the lower set-up varied from 15 to 25 min., and the three lifters and two relief-holes were usually run down in less than an hour. Disconnecting the hose, removing the drills and taking down the cross-bar, and carrying them back to a place of safety in the tunnel, consumed from 15 to 20 minutes.

Blowing out the holes, loading, and splitting generally occupied from 20 to 30 minutes.

Loading the holes, the most critical operation in the cycle, was performed by two machine-men and two helpers—the foreman directly superintending the work and deciding on the proper amount of powder to be used in each hole. A stick of 60-per cent. powder was placed in the bottom of each hole below the primer, and on top of the primer there were usually placed five sticks of powder, except in the cut-holes, each of which received three or four sticks extra. The three lifters were loaded to the collar, the additional amount of explosive being used for the purpose of throwing the muck as far back from the face as possible.

The fuses were always ignited and the charges fired in rotation, the following order being carefully observed:

1.	Short cut-holes, ...	Nos. 1 and 2.
2.	Top cut-holes, ...	Nos. 3 and 4.
3.	Lower cut-holes, ...	Nos. 5 and 6.
4.	Relief cut-holes, ...	Nos. 7 and 8.
5.	Relief back-holes, ...	Nos. 9 and 10.
6.	Top side-holes, ...	Nos. 11 and 12.
7.	Lower side-holes, ...	Nos. 13 and 14.
8.	Back-holes, ...	Nos. 15 and 16.
9.	Corner back-holes, ...	Nos. 17 and 18.
10.	Lower relief-holes, ...	Nos. 19 and 20.
11.	Center lifter, ...	No. 21.
12.	Left-hand lifter, ...	No. 22.
13.	Right-hand lifter, ...	No. 23.

The usual practice of tamping the holes over the explosive was soon discontinued, as it was found that with such heavy charges the powder formed its own tamping, with the further advantage that when the holes were loaded to the collar the rock was more thoroughly pulverized and consequently much easier shoveled into the cars than when lighter charges were used.

Holes will occasionally miss fire, even when loaded with the greatest care; and when no tamping is employed they can be afterwards fired by simply pushing a primer down tightly upon the unexploded charge, without taking the risk of performing that most dangerous of all operations, picking the tamping out of a "missed" hole.

At first, each pair of fuses was lighted about 10 sec. before the next—which, on 40-sec. fuse, gave 3-in. steps on the receding line of fire. This interval, however, being repeated on 10 pairs of holes, occupied considerable time, and the smoke became so intolerable that some method of expediting the rate of fuse-lighting had to be adopted. The one which proved most satisfactory was exceedingly simple. The foreman cut 22 in. from the ends of the fuse protruding from the short cut-holes; 20 in. off the fuse from the upper cut-holes; 18 in. off the fuse in the lower cut-holes, and so on. This automatically provided a difference of 2 in. in the distance the fire had to travel, and, even when the fuse-ends were lighted as rapidly as possible, at least another inch was represented by

the time between the lightings, so that the two shot-firers could secure the necessary interval between the explosions, and yet get away from the face before the smoke from the burning fuse became too dense.

The following tabular recapitulation of the drilling-operations shows that the men could not only complete a round in an 8-hr. shift, but had sufficient extra time to provide for shooting missed holes or taking care of any of the minor difficulties which often arise in tunnel-work:

Periods Occupied in Various Operations.

Exhausting smoke from face,	10 to	12 min.
Picking down roof and sides,	5 to	10 min.
Jacking cross-bar in place,	6 to	8 min.
Attaching drills, making hose- and water-connections,	5 to	15 min.
Drilling from top set-up,	3 hr. to	4 hr. 15 min.
Dropping horizontal bar to lower position,	15 to	20 min.
Drilling on lower set-up,	1 hr. to	1 hr. 15 min.
Removing drills, cross-bar, hose, etc.,	15 to	20 min.
Blowing out holes, loading and firing,	20 to	25 min.
Ignition to explosion of last hole,	8 to	8 min.
Total time required to complete cycle of operations,	5 h. 24 min. to	7 h. 28 min.

Muck from the face was hauled out to the dump in 10-car trains, each car having a capacity of 16.5 cu. ft. A single track of 18-in. gauge, 16-lb. rails, was used for the entire distance, with a passing-switch, located about one mile from the eastern portal. Each train was hauled by two mules, driven tandem.

The empty cars, as they were brought in, were drawn up as close to the loaded train in the face as possible; then they were "stepped" off the track and thrown over on their sides, and the mules were attached to the loaded train, and started for the dump. As each car was fitted with a brake provided with a long handle and ratchet-bar, it was possible to graduate the brake-resistance so that the train could be easily and safely handled on the 1.7-per cent. grade.

As soon as the loaded train had started from the face, two of the empty cars were righted, placed on the track, and pushed up as far into the muck-pile as the track could be cleaned, and the rear car of the two was "stepped" off the

track and thrown over on its side. When the front car had been loaded it was shoved back to a point just beyond the farthest empty car, and the trammers, returning, uprighted and brought back with them empty car No. 3, which was pushed up to the car in the face, which, in the meantime had been righted and loaded; and then No. 3 was "stepped" off and thrown over on its side, to permit loaded car No. 2 to pass out, when No. 3 was instantly righted and placed on the track, and the process of filling it carried on while the trammers were running out car No. 2 and bringing back car No. 4 to the face. This operation was repeated until the entire train of empties had been uprighted and loaded. By this time another train of empties would have arrived from the dump, and the process was continued until the face of the tunnel was cleaned. The number of car-loads broken by a round of holes ranged from 50 to 60.

By reason of the heavy charges used, the rock was thoroughly pulverized and but little picking was required, and, as the floor of the tunnel was kept covered with steel plates $\frac{3}{8}$ in. thick, 3.5 ft. wide, and 7.5 ft. long, shoveling was easily and expeditiously performed with No. 5, D-handled, square-pointed shovels.

Four men were employed in filling, and two in uprighting and tramming the cars. By selecting good men and teaching them how to "muck," it was possible to get the broken rock removed, the tunnel cleaned up, track laid, and the steel plates moved up to within 3 ft. of the new face, by the time the drillers were ready to fire.

Conditions were usually extremely favorable for rapid work; but at times shear-zones were encountered in the granite, where the rock was softened to such an extent that the tunnel had to be timbered. This, of course, put heavy firing out of the question and materially reduced the rate of progress. In May, 1911, the men had great hopes of making over 700 ft. in the month's run. From the 1st to the 25th, inclusive, they had driven 568 ft., when they ran into a softened shear-zone which retarded their progress to such an extent that they drove only 67 ft. during the six remaining days of the month.

From Mar. 1 to Mar. 8, 1911, inclusive, the tunnel was driven, in a single heading, 192 ft., a daily average of 24 ft.; but the highest rate of progress was made during the last four

days of January, 1911, when the tunnel was driven 112 ft., or 28 ft. per day.

The amount drilled each month on the tunnel at both portals is given below, the record month being March, 1911, with a distance of 653 feet:

Monthly Record of Driving Laramie Tunnel.

	East Portal.	West Portal.
1910.		
January,	302	
February,	315	
March,	350	202
April,	354	279
May,	513	336
June,	429	388
July,	443	371
August,	527	293
September,	485	286
October,	420	28
November,	424	
December,	482	
1911.		
January,	609	
February,	420	
March,	653	
April,	583	
May,	635	
June,	576	
July,	497	
August,	106	
Totals,	9,123	2,183
Grand total,	11,306 feet.	

Work on the west heading was discontinued Oct. 3, 1910, because the up-grade haulage of muck, hoisting it through the incline, and pumping out the water which came in from all sides, combined to make the cost per foot much heavier than in the more favorably situated heading from the east portal, where the 1.7-per cent. down-grade gave perfect drainage and greatly cheapened transportation from the face. By this date, moreover, sufficient work had been done to demonstrate that the tunnel could be completed from a single heading within the specified time, so that no risk was incurred by the contractor in restricting operations to the more accessible and more cheaply operated east portal.

During March, April, and May, 1911, the record for distance driven, drilling, powder consumed, and cars of waste sent out was:

1911.	Feet of Completed Tunnel.	Number of Holes Drilled.	Linear Ft. of Holes Drilled.	Avg. Linear Ft. of Holes Drilled Daily.	Sticks of Powder Used.	Cars of Muck Sent Out.
March,	653	1,965	14,330	154	14,808	4,983
April,	583	1,759	12,510	139	16,171	4,765
May,	635	1,985	15,263	164	18,311	5,156

Considering the hardness of the rock, the speed attained in drilling, as shown by the figures above, was exceptionally good; but even these averages fall considerably below what was possible with the equipment used. For instance, a number of the best drill-runners were able to average over 60 ft. of holes per shift, one of them making a monthly shift-average of 61.68 ft.; another of 61.75 ft.; and a third of 61.86 feet.

While this work shows a great advance over current American practice, it still falls behind the records obtained in the best examples of European tunnel-driving. A direct comparison, however, is not quite fair to the United States, since the Alpine tunnels are very much longer than anything yet attempted in this country. At first sight, it would seem that additional length would tend to retard instead of accelerate the rate of progress; but this is not the case. It has been clearly shown that the increased length of transportation and difficulty of ventilation are much more than offset by the improved conditions and the perfection of organization effected by time and experience. As a rule, the greater the magnitude of the undertaking the more thorough the preparation; and the time and labor expended in studying conditions and designing plants for the different Alpine tunnels have been more than justified by the results obtained. European tunnel-engineers have also the advantage of being able to select their employees from an almost unlimited supply of highly-skilled workmen from the Tyrol, Switzerland, and Piedmont, which gives them an incomparably better selection than can be drawn from our heterogeneous labor-supply.

It is, however, confidently believed that, under favorable conditions, with tunnels of sufficient length, thoroughly up-to-date plants, and well-selected crews, backed by careful study

and vigorous management, we will soon be able in this country to equal, or perhaps even surpass, the best European records.

In conclusion, I wish to acknowledge my indebtedness to John A. Davis, of the Bureau of Mines; Charles Hedke, Chief Engineer; B. S. Coy, Resident Engineer; and James A. McIlwee, contractor, for valuable assistance rendered in the collection of data for this paper.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Present Conditions in the California Oil-Fields.

BY MARK L. REQUA, SAN FRANCISCO, CAL.

(San Francisco Meeting, October, 1911.)

DURING the past two years California has developed a new and important oil-field: I refer to Midway. This field produced the famous Lake View gusher, which is credited with a total production in excess of 8,000,000 barrels. Fortunately for the oil industry of the State, this well is now a thing of the past, and nothing save a great crater-like opening marks its location. The pipe is entirely worn away and gone; and it is a matter of serious doubt if there can be anything done that will cause the well to produce again. Fortunately, also, there have been no other wells in that field or elsewhere throughout the State that in any way compared with the Lake View. Midway is noted for large wells, of from 500 to 2,000 barrels production; but the decline is rapid, and a few months serve to bring the output down to a few hundred barrels.

In the oil-territory heretofore blocked out as proved and probable, there have been, during the year, many changes. Some areas which were expected to be fairly productive have apparently failed; others, more strictly "wild-cat," have come in; while in some of the older fields there are properties which are beginning to show evident signs of exhaustion. The total area of proved territory will therefore probably suffer but small increase, when balances are struck off. The increase of new area has come from extensions of the Midway field, the development of a field in Lost Hills and Belridge, and extensions of the Fullerton-Whittier field in southern California. In these later developments, down to date, the fresh area absolutely proved is not much in excess of 3,000 acres. Recent developments in Coalinga indicate the possible extension of that field to the south, but at great depth. Coalinga is still the most northerly field of any consequence in the State. The Kettleman Hills have hitherto brought in nothing, although a

depth of over 3,500 ft. has been reached. Much of the territory proved within the year is extremely deep and expensive to develop and operate.

This, however, is not true as regards a narrow strip in the Lost Hills and the proved tract in the Belridge fields, located respectively 26 and 12 miles NW. and N. of McKittrick. In these fields it is claimed that at depths varying from 600 to 1,200 ft., 200- to 500-barrel wells are the rule, producing oil of 23° gravity and higher. So far as can be foreseen at the moment, this territory is the most disturbing factor in the State, as regards the future price of oil. It is yet too early to predict with accuracy the possibilities of these two fields, and especially of the Belridge territory, but that there is oil underlying the locality at comparatively shallow depths, admits of no question. Thickness of sand, saturation, area proved, and sundry other factors necessary to be determined before any estimate can be made, are as yet not obtainable.

Geologically, the ideas as advanced by the U. S. Geological Survey[1] must be altered, at least as regards the areas through the Lost Hills, and in the immediate vicinity thereof.

In the above-cited reports it is declared that the Vaqueros (Lower Miocene) sands become less saturated as they pass southward, and, although their depth below the surface may be calculated in the Kettleman Hills, it is impossible to determine their depth in the Lost Hills with any degree of accuracy. The inference is that the oil will be here found in the Vaqueros (Lower Miocene) sands, as at Coalinga, rather than in the McKittrick (Upper Miocene) beds, as in the productive fields of the Midway district and other fields to the south, and in smaller quantities.

As is generally understood, the bulk of the oil of the Coalinga field originates in the organic Tejon (Eocene) shales and passes upward into the overlying sands chiefly of the Vaqueros (Lower Miocene) series. In the fields further south, the oil originates in the Middle and early Upper (?) Miocene shales, of similar organic nature, and passes upward to sands of Upper Miocene and Pliocene deposition included in what is known as the McKittrick formation. In the Coalinga field the equivalent

[1] *Bulletin No.* 357, *U. S. Geological Survey*, pp. 120 to 124 (1908); and No. 406, pp. 206 to 209 (1910).

of these Miocene shales is probably what is known as the "Big Blue," which is made up of clay, sand, and gravel, but is not organic in nature, and does not therefore possess the essentials necessary to give rise to commercial oil in this vicinity. Passing southward, however, this member increases in organic contents and thickness, and in the Pyramid Hills gives rise to a distinct petroliferous odor on fresh fracture. The thickness has here been estimated at 1,800 feet.[2]

The increase in the petroliferous nature of these Miocene shales as they pass southward, and the fact that they dip under the plain, to be uncomformably covered by McKittrick beds, indicate a possibility of commercial oil in the latter formation, as well as possibly in the Vaqueros sands. That this is an important condition is shown by the actual development of oil in what has proved to be the McKittrick formation in the Lost Hills.

Aside from the developments in the Lost Hills, Belridge, and Fullerton-Whittier districts, there has been nothing of great moment proved, although certain undeveloped localities are recognized as offering possibilities of production at shallow depth.

Naturally, the sudden increase of production caused by developments in Midway has created a large surplus. Consumption has not kept pace with production; and it is highly improbable that consumption will, at any time in the future, increase in any such proportion as in past years. With comparatively few exceptions, home-markets are supplied, and future increase in consumption must come from the increased demands due to larger population and shipments to South America.

If we assume present daily production over a period of eight months ending Sept. 1, 1911, at 211,000 barrels, and surplus at 34,500 barrels, the daily consumption amounts to 176,500 barrels, or 64,422,500 barrels per annum. Compared with 1909, in which year the actual consumption was about 58,000,000 barrels, the increase is not large.

The annual production of oil in California has been as follows:

---

[2] *Bulletin No.* 406, *U. S. Geological Survey*, p. 63 (1910).

	Barrels.		Barrels.
1875	3,000	1893	470,179
1876	12,000	1894	705,969
1877	13,000	1895	1,208,482
1878	15,227	1896	1,252,777
1879	13,543	1897	1,903,411
1880	40,552	1898	2,257,207
1881	99,862	1899	2,642,095
1882	128,636	1900	4,324,484
1883	142,857	1901	8,786,330
1884	262,000	1902	13,984,268
1885	325,000	1903	24,382,472
1886	377,145	1904	29,649,434
1887	678,572	1905	33,427,473
1888	690,333	1906	33,098,598
1889	303,220	1907	39,748,375
1890	307,360	1908	48,300,758
1891	232,600	1909	58,191,000
1892	385,049	1910 (estimated)	75,000,000

The field-price at present is approximately 30 cents per barrel for fuel-oil and 45 cents per barrel for refining-oil. There is no real reason why this price should not rule lower, as there are apparently some producers willing and anxious to sell at prices considerably below these figures.

Drilling is still active, although much of the work is being done by the Southern Pacific Co., which is reported to be running over ninety strings of tools. On Jan. 1, 1911, the number of rigs drilling was 567; on July 1, 492. For the six months the total production is approximately 38,000,000 barrels. Consumption has not materially increased for the half year; on the contrary, a falling off has been the tendency for the past 90 days.

To-day there is above ground a total of approximately 40,000,000 barrels. The average surplus for the eight months ending Aug. 30, 1911, was approximately 32,000 barrels per day. By months the daily average excess has been, commencing with January, 21,000, 30,000, 57,000, 35,000, 18,000, 33,000, and 32,000 barrels.

It is exceedingly to be regretted that the oil-producers of California, as a whole, do not apparently realize the real cost of production. The older fields cannot hope to materially reduce production-costs. On the contrary, as the deeper territory is drilled, and present producing wells decline, costs must inevitably advance. From territory of, say, 2,500 ft. depth,

total costs will approximate from 30 to 35 cents per barrel. For direct production—*i.e.*, pumping, cleaning, and pulling—10 cents per barrel may be safely assumed. For maintenance of surface-equipment and rigs, 4 cents is a conservative estimate. For exhaustion of oil-land, and redemption of capital, from 6 to 10 cents must be reckoned; and for drilling to maintain production, 12 cents is not excessive. These figures make a minimum of 32 cents and a maximum of 36 cents. It is obvious that for any business in which the risk is as large as in the drilling of oil-wells, the resultant profit should be in proportion to the risk involved. Under existing conditions in California, this is most emphatically not the case.

The recent agitation which has brought about the dissolution of the Standard Oil Co. has in no way benefited the small producer. On the contrary, the situation has been rendered, if anything, more acute. Because of its self-contained character, as producer, transporter, refiner, and marketer, the Standard Oil Co. was able to earn a profit when the small producer was confronted with a loss. Regulating prices, even within modest limits, by agreement is apparently to-day a criminal act. Because of this, it is not possible to reach any agreement with the great factor in the California oil industry, and we have the spectacle of the Standard Oil Co. of California exerting a stronger and stronger domination, and the small producer getting deeper and deeper into financial difficulty.

The utter failure of "trust-busting," so far as the commercial relief of California oil-producers is concerned, is self-evident. It would be much more to the point if conditions were frankly faced as they exist, and regulation of output and prices permitted, if necessary, under government supervision. What is being aimed at might be accomplished in that way. It is certainly not being accomplished at present by the absurd methods now pursued. The Standard Oil Co. of California, operating as a strictly local institution purged and purified from contaminating associations with the parent company, can quite as effectively dominate the fields as did ever the parent. And unless we turn anarchists pure and simple, and confiscate property and ignore vested rights, there is absolutely no way of curing the trouble save by pools and agreements recognized and encouraged by law. What is true of the Standard as to

the cost of doing business will apply in less degree to the Union Oil Co., and to the Associated Oil Co. in still less degree, because the latter company is not in the refining business. To the small producer, who depends for his profit on taking the oil from the ground and selling it to the transporting and marketing companies, the present conditions spell ruin unless corrected in the near future.

The waste of oil is appalling. Brought to the surface, it is allowed to lie for months in open earthen sumps. Storage-tanks of steel, concrete, and earth are full to overflowing; and yet the daily surplus of from 31,000 to 50,000 barrels accumulates, and is in part dissipated by evaporation. Probably not less than 4,000,000 barrels, and possibly double this amount, of oil was lost last year by evaporation and seepage. This year will see quite as much similarly dissipated. Much of this loss could be eliminated by agreement among the producers. Practical conservation would be along lines of restricted production, permitting the oil to remain in its natural reservoirs underground until such time as it can be produced and sold at prices that will yield a reasonable profit to the small producer. To improve prices and relieve surplus, suggestions have been made that large quantities of oil be burned. This would be an attempt to conserve prices at the expense of natural resources. The mere suggestion of such a remedy for a condition that need not exist if sane conservation were effective, is sufficient commentary on the utter inability and ineffectiveness of theoretical cures. Thanks to existing laws, it seems that we must continue to recklessly squander our resources and rob the State of one of its greatest assets without satisfactory return.

On the Pacific Coast of North and South America there has as yet been developed no deposit of coal equal in quality to the best eastern Australian or Welsh products. The cost of the non-uniform article which is found and mined in Washington and British Columbia is much higher, as must also be similar products awaiting development in Peru and Alaska. Excess in these coal-costs and the poor quality of the article have, heretofore, not only retarded various industrial developments, but hindered manufacturing enterprises on the Pacific Coast. This condition, however, paved the way for the intro-

duction, eager use, and marked success of the fuel par excellence in steam-generation—California oil.

A few comparative statements showing its superiority to coal in point of heat-value and economy in firing boilers follow:

California oil in general use and under identical conditions gives uniform results. The evaporative power of the Pacific Coast coals varies greatly. Under horizontal boilers, 1 lb. ot California oil should evaporate from 13 to 15 lb. of water. One pound of the best coal in use on the Pacific Coast will hardly evaporate 9 lb. of water, and 6 lb. is the figure for poorer grades. Taking the ratio of the two fuels in point of evaporation efficiency as 14 lb. to 8 lb., or 1.75 to 1, we find that 1,280 lb., or 3.8 barrels, of fuel-oil is equivalent to one long ton, or 2,240 lb., of coal. In transportation-cost, the advantage in favor of pipe-line is so great that the cheapest rail-transportation cannot compete, although water-shipments come nearer to so doing. Loading- and unloading-costs, losses from wastage and theft, and the difference in stoking-expenses are to a high degree in favor of the liquid fuel.[3]

"Probably no more striking way of actually showing the relative commercial value of coal and oil as a fuel, could be presented than by stating that the Atchison, Topeka and Santa Fé Railroad Company made the following comparative tests, of the cost per train mile, of coal costing $6.65 per ton and petroleum costing $1.33 per barrel.

"Twenty-five passenger and freight engines on a thirty-day run, used 2,077 tons of oil and traveled 87,063 miles, or 41.9 miles per ton, or 3,500 miles per month per engine. Oil at $1.33 per barrel would, at this figure, cost 14.4 cents per mile. Twenty-five passenger and freight engines (same days, same track, and same condition) burning coal, cost 23.2 cents per mile. The oil was 15° Baumé, about the same as the Kern River oil, which is 14° and 17° Baumé; this showed a saving for oil of 38 per cent., and the experiment was tried with coal at $6.65 per ton.

"In this extended and practical test the cost of the oil per barrel was one-fifth of the cost of the coal per ton, while the resulting gain for oil was 38 per cent. Stated in another form, the value of the two fuels would be the same when the price of the coal in tons was three and one-half times the price of the oil in barrels."

The following tables, extracted from a report compiled at my request by George W. Dickie, consulting marine engineer, of San Francisco, will be of interest in practically illustrating

---

[3] *Report of U. S. Naval "Liquid Fuel" Board*, Bureau of Steam Engineering, U. S. Navy Department, pp. 390 to 391 (1904).

the proposition. Oil is figured at $1 per barrel. Indicated horse-power of steamer, 3,000; steaming speed, 11 knots.

"A."

Cost of Oil Fuel Per Day.	Quality of Coal in B.t.u. Per Pound.	Tons Coal Per Day.	Added for Additional Labor.	Cost Per Day for Several Qualities of Coal at the Following Prices Delivered.		
				$4.	$6.	$8.
	12,000	62.70	37.56	$288.36	$413.76	$513.16
$300	11,000	68.40	37.56	311.16	447.96	584.76
	10,000	75.20	37.56	338.36	488.75	639.16
	9,000	83.60	37.56	371.96	539.16	706.36

"B."

A vessel engaged in coastwise traffic between California ports:	
Oil-consumption per trip, 4,000 barrels,	$4,000
Firemen, wages and food,	275
Total cost,	$4,275
Coal-consumption per trip:	
1,200 tons, at say $4,	$4,800
Firemen, wages and food,	1,000
Total,	$5,800
Saving per trip in favor of oil,	$1,525
Assuming two voyages per month, the saving is,	3,050
Allowing 11 months' operation per year, yearly saving,	33,500
Or, 6 per cent. on a sum slightly under,	560,000

This figure of $1 per barrel at San Francisco bay would equal about 65 cents net to the producer at the well.

The United States Geological Survey has estimated the contents of the probable oil-lands in the United States as follows:

Probable Oil in United States.

	Minimum. Barrels.	Maximum. Barrels.
Appalachian field,	2,000,000,000	5,000,000,000
Lima-Indiana field,	1,000,000,000	3,000,000,000
Illinois field,	350,000,000	1,000,000,000
Mid-Continent field,	400,000,000	1,000,000,000
Gulf field,	250,000,000	1,000,000,000
California field,	5,000,000,000	8,500,000,000
Minor fields,	1,000,000,000	5,000,000,000
Total,	10,000,000,000	24,500,000,000

In other words, of the minimum of 10,000,000,000 barrels, California is credited with one-half of the entire possible produc-

tion of the United States, and of the possible maximum, California may possibly produce one-third.

Personally, I believe that the maximum will unquestionably be in excess of 8,500,000,000 barrels for California. The total production for the State to Sept. 1 was approximately 434,000,000 barrels, leaving a very large percentage still underground. It is safe to say that California oil will dominate the fuel-market on the Pacific Coast during the present century and probably far into the next century. Unless consumption is tremendously increased, this is undoubtedly true. These figures are, of course, only relative approximations, but are sufficiently accurate to warrant the assertion that California oil will dominate the fuel-market of the Pacific at least through the present century.

Comparing California oil with Alaska coal, it is apparent that oil has complete control of the field.

Alaska coal can be landed at Puget sound ports for approximately $4 per ton.[4]

Assuming 3.5 barrels of oil as equal to one ton of coal and oil at 50 cents per barrel at the well, its comparative cost with coal per ton delivered on Puget sound would be $3.50, and with oil at 75 cents at the well, this cost should not exceed $4.20. At prices even in excess of this, consumers would not return to coal, owing to the many indirect advantages accruing to the burning of oil. Costs at other points depend entirely upon distance by sea. Assuming Valparaiso, Chile, as the southern, and Douglas Island, Alaska, as the northern extreme, with oil at 60 cents per barrel at the well, coal must sell at $5 per ton at Valparaiso, and $3.50 at Douglas Island, in order to equal oil in fuel-value. This takes into consideration due allowance for interest, redemption-funds, depreciation, and transportation. When the prices of oil are yet higher coal cannot compete, because the oil is so much more satisfactory in every way, and has so many advantages, that the cost of coal would have to be materially less to induce the abandonment of oil. In view of the above statements, it is fair to assume that during the life of the fields there will be no fear of competition from coal until oil is selling above 75 cents per barrel.

[4] *Bulletin No.* 442, *U. S. Geological Survey*, p. 88 (1910).

Recent experiments indicate the possibility of oil being used for domestic purposes, even in small dwellings. I am using it in my home for both cooking and heating, to the entire exclusion of coal; and a more recent device seems to make the installation-cost so small as to open the entire domestic field to oil-competition. If so, the consumption of coal will practically cease in California, and the public will cut its fuel-bills more than 50 per cent.

The action of the government in withdrawing certain territory is a step in the right direction. Additional drilling at this time would benefit no one, and would be an additional menace to an already overburdened situation. There is no storage so satisfactory as that afforded by the underground reservoirs from which the oil comes. It is free from costs of any kind, and seepage and evaporation are entirely eliminated. Some plan, however, should be decided upon, whereby the land will be available when needed. Leasing under certain restrictions would seem to be a logical solution. At present it would be folly to open in any way this withdrawn area. Territory now producing can care for consumption for an indefinite period. As a suggestion, I should say that government land should not be leased so long as oil at the well sells for less than 60 to 70 cents per barrel, and that, on leases so granted, no new drilling should be permitted when prices rule below this figure. This would be sane and practical conservation, as it would permit production only in times of need, and would conserve a great natural resource that, once exhausted, can never be replaced.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Parral-Tank System of Slime-Agitation.

BY BERNARD MACDONALD, GUANAJUATO, MEXICO.

(San Francisco Meeting, October, 1911.)

Introduction.

Of the treatment of the slime-pulp of gold- and silver-ores by cyanidation, agitation is an essential part. When prepared for treatment, this pulp, consisting of ore reduced to such fineness that approximately 80 per cent. of it will pass through a 200-mesh screen, is mixed with a certain proportion of water, carrying in solution the quantity of cyanide (KCN) and other chemicals required.

The water-constituent of the pulp thus prepared usually ranges from 1 to 2 parts by weight to 1 of the dry ore. Thus constituted, the pulp is charged into treatment-tanks, the shape and capacity of which vary, according to the quantity of pulp to be treated daily and the method of agitation to be employed. Tanks have no other function in a cyanide-plant than that of being economical and convenient containers or receptacles for holding the pulp, solution, or water used in the operations.

It is by agitation that the solids in the pulp charged into the tanks are kept in suspension in, and mixed with, the solution in the proper proportions required for the treatment. If the proper mixture of solution to solids be determined to be 2 to 1 by weight (which is, approximately, 5 to 1 by volume), this proportion should be maintained in every part of the charge; that is, each solid particle of the pulp, whether it be of 180- or 400-mesh size, should be surrounded by five times its own volume of solution throughout the whole period of treatment. The reason is, that the amount of chemicals ascertained to be necessary for dissolving the gold and silver contained in the solids, is held in uniform solution in the water-constituent of the pulp, and, therefore, the determined proportions of solution and solids must be maintained at all times during treat-

ment. If the pulp should be allowed to thicken at the bottom of the tank so that it would contain, by volume, say, only 4 parts of the solution to 1 part of solids, it is plain that there would be present in this part of the tank-charge only four-fifths of the chemicals necessary for the treatment of the solids, while the one-fifth lacking would be present in another part of the tank-charge where it was not required. This principle, the importance of which is not always appreciated in the operation of a cyanide-plant, is the main ground of the necessity of agitation. But, besides maintaining the proper proportional mixture of solution and solids in the tank-charge, agitation is designed to give the required "aeration" to the pulp during treatment.

Means of Effecting Agitation.

In the cyanide-plants built before 1907, agitation was effected in tanks 10 to 12 ft. deep, and ranging in diameter up to 30 ft., by mechanically revolving stirring-arms, assisted by centrifugal pumps drawing the settled pulp from the bottom of the tank and throwing it back on the top of the charge in the same tank. This method was fairly efficient, but expensive in both the construction and the operation of the plant; and it was superseded by pneumatic or air-lift agitation, which proved to be at least equally efficient, and much more economical.

The method of air-lift agitation which came into general use in cyanide-plants is known as the Pachuca-tank system. The superior economy of air-lift agitation and the energy of the patentees of this system soon brought this method into popularity, and most of the recently constructed cyanide-plants have adopted it.

Analysis of the Pachuca Tank and Its Operations.

Fig. 1 is a sketch of the Pachuca tank and its pipe-equipment. Beside it is shown a Parral tank of equal holding-capacity, Fig. 2. The Pachuca tank is a tall cylinder with a conical bottom. In the center of the tank is fixed the air-lift tube, which, commencing about 18 in. from the apex of the bottom, extends to within a few inches of the top of the tank. The diameter of this tube is proportioned to the diameter of the tank as 1 to 12 approximately.

In Fig. 1, *AA* are the sides of the tank; *BB* is the air-lift tube; *CC*, the pipe which delivers the compressed air into the bottom of the air-lift tube; *D*, the foot-rest which holds the compressed-air pipe in the center of the air-lift tube; *EE*, an auxiliary compressed-air pipe used for delivering compressed air at the bottom of the tank, to keep the pulp in agitation while the charge is being received; *FF*, a system of pipes extending radially from a hollow "bustle" or distributor attached

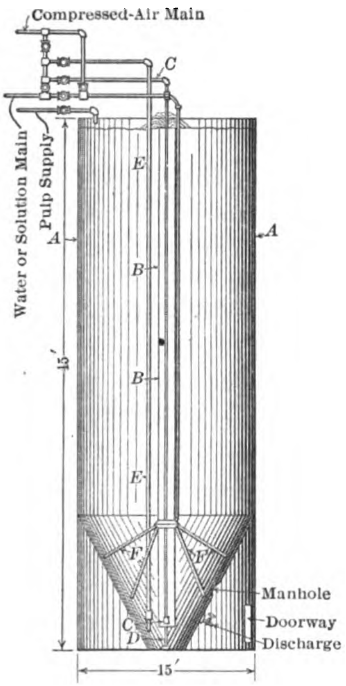


Fig. 1.—Pachuca Tank.

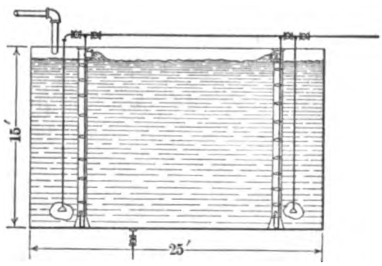


Fig. 2.—Parral Tank.

FIGS. 1 AND 2.—PACHUCA AND PARRAL TANKS OF APPROXIMATELY EQUAL HOLDING-CAPACITY.

to the air-lift tube, to which is connected a feed-pipe leading from the air-main at the top of the tank, through which feed-pipe compressed air or solution under pressure may be turned into the bottom of the tank, to assist in agitating the pulp while the tank is being charged, or, in case of packing, to restore the pulp to a fluid consistency so it can be moved through the air-lift tube.

The compressed-air, high-pressure solution, and pulp-charging mains for the pipe-connections are shown at the top of the tank. It should be noted that the end of the compressed-air pipe, *CC*, is capped, and, for a length of about 7 in. next to the cap, is perforated by a number of small holes through which the compressed air escapes into the air-lift tube. To prevent the pulp from entering these holes and choking the pipe, when the compressed air is shut off, a tight-fitting rubber stocking or tube is drawn over the holes and clamped to the pipe above them. When the air is on, this stocking expands and the air flows underneath it and escapes at its lower end, which is left open. When the air is shut off, the stocking closes over the perforations and prevents the pulp from entering them.

In operation, when the tank is receiving its charge from the pulp-charging main, compressed air is turned on through pipe *EE* to keep the pulp in agitation and prevent it from settling in and around the bottom of the air-lift tube.

In case the compressed air fails during the charging of the tank, and the pulp packs so hard around the bottom of the air-lift tube and the rubber stocking as to prevent the operation of the air-lift when the compressed air comes on, air, or solution, or both, may be turned into the auxiliary pipes *EE* and *FF*, to bring back the packed pulp to fluid consistency; and, in case this fails, the tank is provided with a man-hole, shown in the figure, which may be opened, and the packed pulp excavated.

When the tank has received its full charge of pulp, compressed air is turned on in pipe *CC*, which starts the operation of the air-lift tube, and the auxiliary air-agitation pipes are then closed off. By the operation of the air-lift tube, the thick pulp at the bottom of the tank is drawn into and carried up through it, and discharged at the top, where it falls back on the tank-charge and mingles with the thin pulp there.

The transfer of the pulp from the bottom to the top of the tank continues throughout the treatment-period, and preserves the proper proportional mixture of solution and solids. By these means and in this manner, the agitation of slime-pulp is effected by the Pachuca-tank system.

Defects of the System.

That this system was a great improvement over any other previously employed, there is no question; but that it has a number of commercial defects, is also true.

All these defects result from the design of the tank, and the apparatus with which it is equipped, the tank-dimensions being at variance with all the principles governing the object (other than as stand-pipes) for which tanks are employed. The great height and small diameter make the holding-capacity comparatively small, and consequently its cost of construction per unit of holding-capacity, high. The height of the tank and the large diameter of the air-lift tube necessitate a correspondingly high pressure and a large volume of compressed air to effect the transfer of the pulp; and this adds to the cost of agitation.

The pulp transferred through the air-lift tube overflows on the top of the charge, close around the tube, in which relative position the solid particles settle vertically to the bottom, where the steeply-sloping sides of the cone bottom carry them to the intake of the lift-tube, which throws them back again on the top of the charge. Under normal conditions of operation, the air-lift tube turns over the entire charge in a Pachuca tank of standard size in about 15 min. The violence of this operation would not be necessary to keep the pulp in proper mixture; but on account of the tall, narrow tank and the conical bottom, it is necessary, in order to keep the air-lift tube and the air-nozzle from being choked.

The air-nozzle within the lift-tube is a crude mechanical device, expensive to operate and expensive to maintain.

Before the proofs for these assertions are submitted, the principles of air-lift pumping should be reviewed. Those who have never had occasion to investigate the phenomena of air-lift pumping will find the subject fully dealt with in the experiments and conclusions of Dr. Pohle, who obtained a patent from the United States for the use of compressed air in pumping.

From Dr. Pohle's experiments and those made by myself, my understanding is that pumping by compressed air is effected in the manner described below, with due reference to

the conditions of the air-lifting or transfer of pulp in a tank for the purpose of effecting agitation. At the starting of agitation, after the tank has received its charge, the pulp-level is the same within and without the air-lift tube, which extends, say, 3 or 4 in. above the pulp-level. If the pulp has the consistency of 2 to 1 of solution and solids, the pulp-pressure on the bottom of the tank will be 0.54 lb. for each foot in height of tank-charge. The air-pressure for the agitation of such a charge should be 10 per cent. greater, or, say, 0.60 lb. for each foot in height of the charge. When the compressed air at this pressure is turned on in the air-pipe terminating near the bottom of the lift-tube, it flows into the pulp there, which has a pressure of only 0.54 lb. per foot of height. The compressed air, on entering the pulp in the lift-pipe, assumes the form of bubbles; and these, rising through the pulp, immediately unite to make a large flattened bubble which, extending to the sides of the pipe, takes the form of a disk or piston, in which form it rises to the surface, pushing the pulp before it. Rivalry now begins between the pulp and compressed air for the privilege of filling the space vacated by the ascending air-disk. The pulp, endeavoring to restore the hydrostatic equilibrium between the contents of the air-lift tube and those of the tank outside, and aided by its greater volume (due to the disparity of size between the compressed-air and air-lift tubes), rushes past the air-nozzle, holding back for a moment the issue of air. But immediately the air, on account of its higher pressure, again succeeds in entering the lift-tube in sufficient quantity to form another air-disk, with the same result as before. Thus by frequent jets of compressed air, alternating with rushes of pulp into the bottom of the air-lift tube, the lifting-operation is effected. The *modus operandi* of the air-lift, as above briefly described, is disputed by some, who hold that the inflow of air is continuous, and that the lifting effect is produced by the formation of a large number of bubbles in the pulp in the lift-tube, which makes it lighter, and, consequently, subject to displacement by the heavier pulp in the tank outside, rushing in at the bottom of the tube, and causing the discharge of the lighter pulp at the top.

A little study will show that this apparently logical reason-

ing cannot account for the operation of the air-lift, for individual bubbles rising through the liquid in the air-lift tube could have no more effect in lessening the hydrostatic pressure at its intake than would so many corks rising through it. On the contrary, it will be readily seen that, were the corks to unite and form disks or pistons filling the pipe, these disks would, on rising through the lift-pipe, carry the intervening pulp upward with them.

It is not improbable, however, that in certain kinds of liquids having great viscosity, the inflow of compressed air would be imprisoned as numerous small individual bubbles, and would in this way form an emulsion of the liquid within the tube, which emulsion, being lighter than the pulp outside, would be lifted or shoved upward by the heavier pulp coming in to displace it. But this condition would not be probable in the case of an ore-slime.

The principal defect of the air-nozzle of the Pachuca tank is the amount of ineffective work that must be done by the compressed air in making its numerous jet-like escapes into the air-lift tube. The superficial area of the exterior of the rubber stocking, that must open and close for each jet of air escaping, is 36 sq. in. at least; and on each inch of this area there is a continuous pressure of 0.54 lb. per foot in height of the tank-charge. As filled in operating, there are 43 ft. of pulp in the tank, making an external pressure of 23.22 lb. per square inch, or a total of 836 lb. on the movable part of the stocking; and this weight must be lifted by each jet of air admitted to the air-lift tube. In view of the great frequency of the air-jets, the enormous amount of useless work which this form of valve necessitates will be apparent. Moreover, the numerous alternate openings and closings of the rubber stocking soon destroy its elasticity and wear it out. The difficulties attending agitation in Pachuca tanks are described by Huntington Adams, in a paper read at the Wilkes-barre meeting of the Institute, and need not be repeated here.[1]

It should also be understood that the efficiency of air-pumping is affected by dimensions of apparatus, etc., differently from that of mechanical pumping. For instance, a mechanical pump

[1] *Bulletin No.* 56, August, 1911, pp. 595 to 601.

designed for a 6-in. discharge-pipe will pump as easily the same quantity through a 16-in. discharge. But in the case of air-lift pumping, the volume and pressure of compressed air that would be sufficient to pump violently through a 6-in. discharge-pipe will have no lifting-effect whatever through a 16-in. pipe; for the compressed air would rise in a stream of separate bubbles through the liquid in the lift-pipe, and would not be of sufficient volume to form solid air-disks reaching from wall to wall of that pipe; hence the liquid column would be unbroken and would itself be in hydrostatic balance with that outside the lift-tube, and no displacement would result. This points to the economy of using the smallest air-lift tube consistent with the volume of liquid to be pumped.

The Parral-Tank System of Slime-Agitation.

In this system, designed and developed by me, for which United States and Mexican patents have been obtained, the defects in the Pachuca-tank system above referred to have been eliminated, and corresponding advantages secured.

A complete tank-equipment of this system, consisting of five tanks, and capable of treating 500 tons daily, has been installed at the milling-plant of the Veta Colorado M. & S. Co., at Parral, Mexico. Besides the Parral tanks there are two standard Pachuca tanks, one of which is used as a treatment-tank, and the other for holding the wash-water for the filter-press plant.

The Parral tanks, 25 ft. in diameter and 42 ft. high, are equipped with the special piping and the apparatus peculiar to this system, while one Pachuca tank is equipped with the piping and apparatus of that system. The treatment-tanks (*i. e.*, the one Pachuca and five Parral tanks) have been piped for the individual and continuous systems of treatment, and each of these systems has been tried out, separately, a complete record of the results being carefully kept. No advantage in the extraction of values has been shown by either of these systems over the other; but the continuous system is more economically operated by reason of its great simplicity and "fool-proofness."

Fig. 3 shows the battery of treatment-tanks. On the extreme right is the Pachuca tank, on top of which sits the deck-house

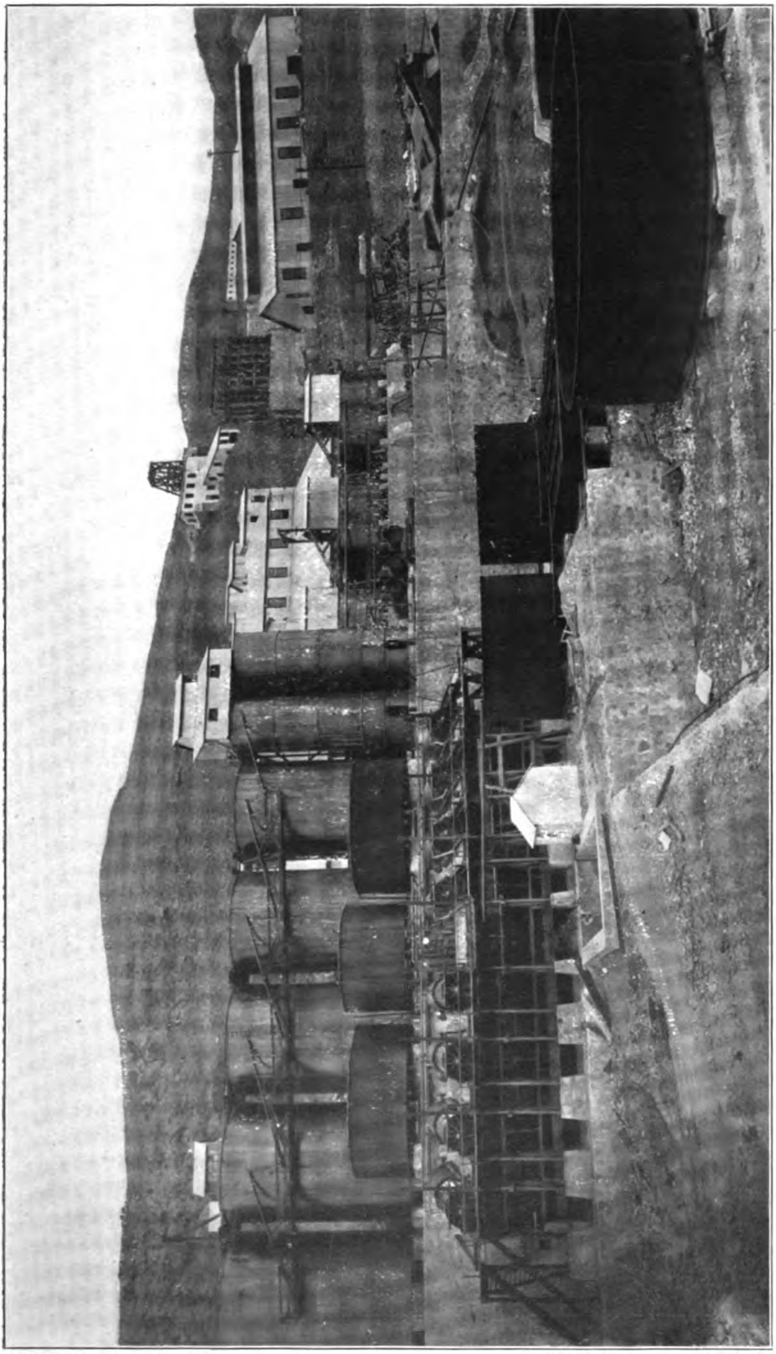


Fig. 3.—Slime-Treatment Plant of the Veta Colorado M. & S. Co., Parral, Mexico.

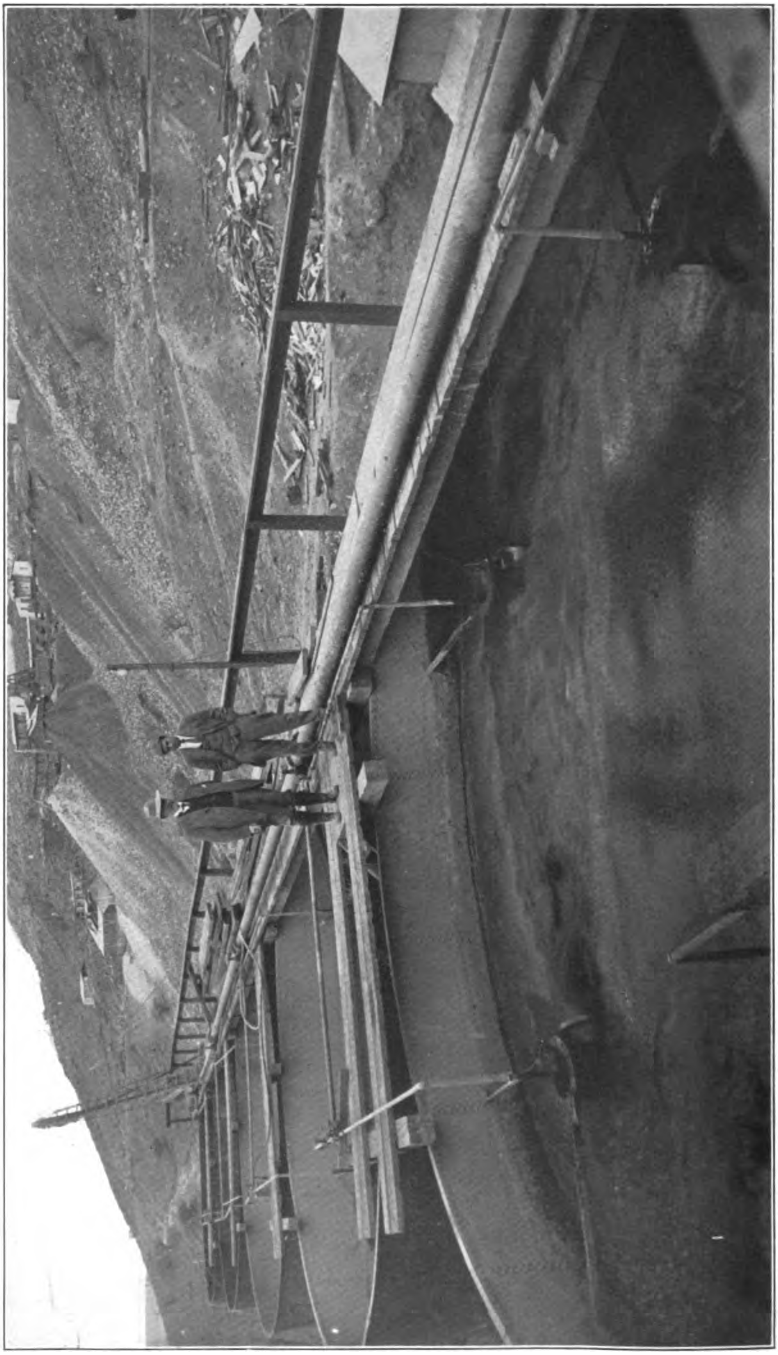


FIG. 4.—VIEW OF TREATMENT-TANKS OF VETA COLORADO M. & S. CO., SHOWING PULP-DISCHARGE FROM TRANSFER-PIPES.

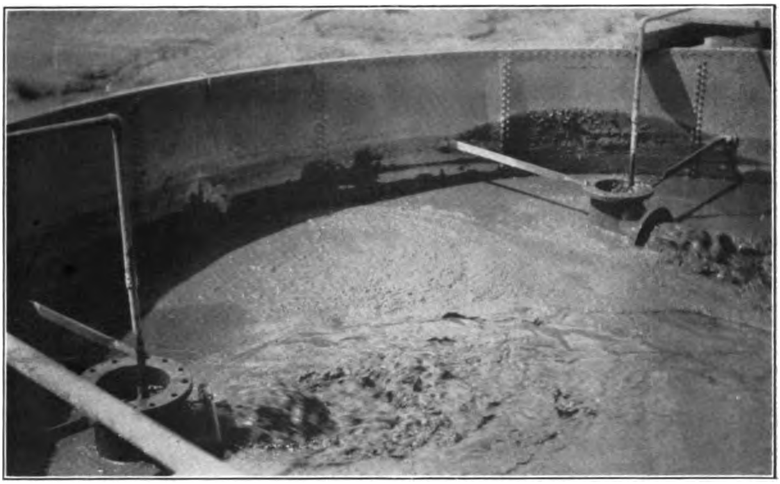


FIG. 5—ROTARY FLOW OF PULP IN PARRAL TANK.

FIG. 8.—COMMENCEMENT OF PULP-TRANSFER IN PARRAL TANK.

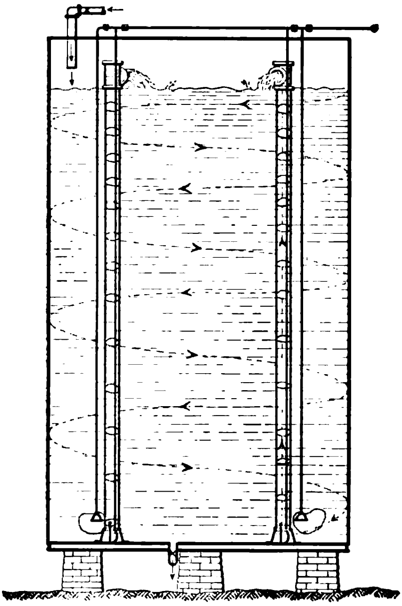


FIG. 6.—PHANTOM-VIEW OF PARRAL TANK, SHOWING ALTERNATE DISKS OF COMPRESSED AIR AND PULP ASCENDING THE TRANSFER-PIPE AND ROTARY TRAVEL OF PULP-PARTICLE.

FIG. 7.—TOP-VIEW OF PARRAL TANK, SHOWING ROTARY MOTION SET UP BY DISCHARGES FROM THE TRANSFER-PIPES.

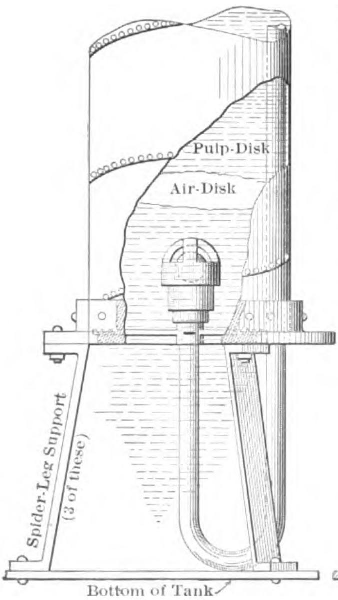


FIG. 9.—COMPRESSED-AIR NOZZLE IN TRANSFER-PIPE OF A PARRAL TREATMENT-TANK.

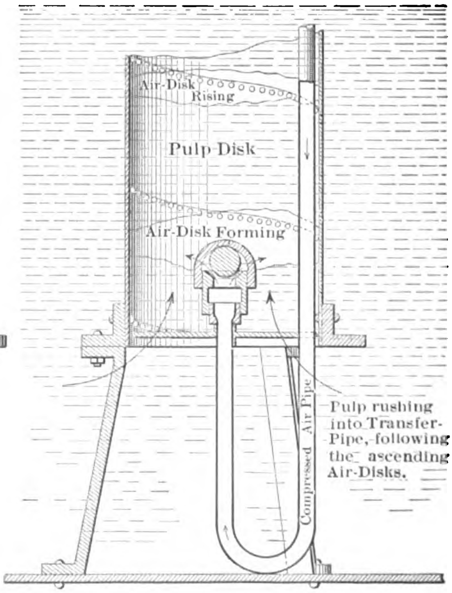


FIG. 10.—SECTION THROUGH TRANSFER-PIPES IN PARRAL TANKS.

used for the titration of samples, while in the same row to the left are the five Parral tanks. Along the front of the tanks near their top are seen the piping for the continuous-treatment system, and the sampling-platform. In the center and lower left corner are shown the "excess" tanks and the battery of Kelly filter-presses appurtenant to the plant.

The object of the Parral-tank system of agitation is the same as that already described in reference to the Pachuca tank, but the tank-design and the mechanical equipment used are entirely different from those of the Pachuca system.

The Parral tank is flat-bottomed, 25 ft. in diameter and 42 ft. high, with a capacity three times as great as that of the standard Pachuca tank. For transferring pulp from the bottom to the top of the tank, four 12-in. transfer-pipes are set 12 in. from the bottom, 4 ft. from the tank-side and equi-distant from each other. The compressed air is admitted into these pipes through a patent nozzle fitted with a ball-valve, which automatically opens and closes, intermittently, as required in the jet-feeding of the compressed air. I refer to these as transfer-pipes, this being more accurately expressive than lift-pipes, for, practically speaking, the pulp is not lifted, but transferred from the bottom to the top of the charge.

In case the compressed air should fail, and in the momentary intervals between the jet-issues, the air-nozzle is securely and automatically sealed by the ball falling back on its seat, and the entrance of pulp to the air-pipes is prevented.

On the delivery- or top-ends of the transfer-pipes, tees of equal diameter are bolted, with the run in line with the pipes, and the outlets so directed as to discharge the pulp in line of segment-chords to the circumference of the tank. The discharge of all the transfer-pipes is in the same direction, and the force of the discharge sets up a spiral or rotary flow in the tank-charge which, in a short time, extends down to the bottom of the tank.

Figs. 4 to 7 show the pulp discharging from the transfer-pipes, and the undulations of the rotary flow set up in the tank-charge. The delivery-ends of three of the four transfer-pipes are shown in Fig. 4, but the rotary flow is perhaps more clearly seen in Fig. 5. When Parral tanks are receiving their charge for individual charge-treatment, an auxiliary air-pipe is ex-

tended down alongside each transfer-pipe to a point near the bottom of the tank, and the compressed air issuing from these pipes keeps the pulp in agitation and prevents its settling on the bottom. In the continuous system this pipe is never used.

When the tank is filled to within 10 or 12 ft. of the top, the air is closed off the auxiliary pipes and turned on in the transfer-pipes. Fig. 8 shows a workman making this change and the transfer of the pulp (lift at this time) commencing. This figure shows also the method of making the transfer-pipes fast to the side of the tank, which is very secure and simple.

The spiral flow set up in the tank, as shown in Figs. 6 and 7, carries the pulp-particles round and round, so that the distance traveled by the pulp from the time it is delivered at the top until it reaches the bottom is many times greater than if it settled vertically, as in the Pachuca tank. In other words, the solids are carried in suspension by the rotary flow of the solution as they would be carried in a flowing river; the settlement of the heavier particles is thus retarded; and, consequently, the necessity for transferring the pulp from the bottom of the tank to the top is proportionately lessened, and the cost of the work is comparatively reduced.

In the Parral-tank system no special diameter of tank need be adhered to as in the Pachuca system. The relation of the diameter to the height of the tank may be whatever is economical in holding-capacity, which should be the main consideration in determining tank-diameters.

To secure, under this system, perfect agitation and the necessary rotary flow in tanks of the largest diameter, it would only be necessary to install a proper number of transfer-pipes, with discharge-outlets placed in the right direction to set up and maintain the rotary flow. A Parral tank (see Fig. 2), of the same holding-capacity as a standard Pachuca tank, would be 15 ft. in height by 25 ft. in diameter, and would be equipped with four 8-in. transfer-pipes; while the necessary pressure of compressed air would be only 8.5 lb. per square inch. The comparative cost of construction and operation of these two types of tanks is easily estimated.

TABLE I.—*Comparison of Corresponding Items in Standard Parral and Pachuca Tanks.*

Points of Comparison.	Dimensions or Number. Pachuca.	Parral.
Height in feet,	45	15
Diameter in feet,	15	25
Horizontal area in square feet,	176.7	490.8
Effective holding height in feet,	39	14
Holding-capacity in cubic feet,	6,891.3	7,671.2
Holding-capacity in metric tons of solids:		
Pulp-ratio: Solution 2, solids 1,	83.3	92.8
Solution 1.5, solids 1,	125.3	139.4
Solution 1, solids 1,	139.5	155.3
Weight of steel plate and all construction-material in pounds,	33,000	14,650
Pounds steel per ton of 2:1 pulp,	400	157
Pounds air-pressure required for agitation,	30 to 50	8 to 10

The compressed-air nozzle with its ball-valve, which was designed and patented for the Parral-tank system of agitation, may be used in any air-lift, and makes for the highest possible efficiency of compressed air used as a lifting agency. Figs. 9 and 10 illustrate the construction and operation of this valve. An examination of the ball-operation will show that the pressure on it, due to the hydrostatic head of the pulp-charge, is balanced, except for the area of the ball that rests on the seat. The seat-area of the valve, which is 2 in. in diameter, equal to a horizontal area of 3.1416 sq. in., would leave an unbalanced weight of 73 lb. on the ball, if it were to replace the rubber stocking in the Pachuca tank—or 763 lb. in favor of the ball-valve.

As the air-nozzle is called upon to open and close several times each second in permitting the jet-discharge of compressed air into the transfer-pipe, the aggregate of the useless work which the rubber stocking imposes on the compressed air, and the comparative advantage which the ball-valve possesses over it, will be easily estimated. My reason for saying that the probable frequency of the air-jet discharge will amount to several per second, is, that the sounds of the seatings of the ball-valves, as heard by one going underneath the tank, seem almost as frequent as the blows of an air-hammer.

So far, I am not able to fix any period as the useful life of the Parral valve; for these valves have been in operation since

the starting up of the plant, Feb. 6, 1911, and, at a recent date, had shown no signs of wear.

For comparison between the two valves on this point, it may be noted that the Panilla mill contains 12 standard Pachuca tanks, 10 of which were equipped with the rubber-stocking valve of that system, and 2 with the nozzle and ball-valve of the Parral-tank system. These tanks began operation on the first of January of this year; and the rubber stockings soon wore out and were replaced by Parral valves, while the Parral valves originally installed showed, when recently examined, no signs of wear and are apparently as good as ever. In this plant and in that of the Veta Colorado M. & S. Co., the Parral valves never gave any trouble in starting up, even after the air had been closed off for three hours at a time; while, under the same conditions, the valves of the Pachuca tanks were only started after a great amount of trouble.

Although the transfer-pipes in the Parral tanks are 12 in. in diameter, I believe 6-in. pipes would produce sufficient rotary flow in the tank-charge to give the required agitation. In the operation of the tanks installed, when the transfer of the pulp is started and a strong rotary motion (about 10 ft. per second) communicated to the tank-charge, the air-valve is turned down until the flow of pulp from the transfer-pipes is reduced to one-third of their normal capacity, and so continued to the end of the treatment. By repeated tests, it has been shown that the extraction of values was as good with one-third the normal capacity of the transfer-pipes as when they were being operated at full capacity. From these tests it has been deduced that, so long as the spiral flow in the tank is maintained at a speed sufficient to retard materially the vertical settlement of the solids, so as to keep them suspended in proper proportion in the solution, the extraction of gold and silver proceeds just as rapidly as when the pulp is violently agitated.

I have no exact data from which to form an estimate of the comparative amount of air consumed per ton of pulp treated in the two systems, for the air has never been metered; but engineers who operated the valves on the air-pipes of both tanks, experimentally, with a view to estimating the flow of air by the proportional valve-openings, have reached the conclusion that it does not require more air to operate the four 12-in. transfer-

pipes of the Parral tanks than the one 16-in. transfer-pipe of the Pachuca tank; and I venture my personal opinion that when a meter-test of the air-flow is made, this conclusion will be confirmed.

The comparative dimensions of the Parral tanks, as installed at the mill of the Veta Colorado M. & S. Co., and of the standard Pachuca tanks, with the individual equipment of each, are given in Table II. It may be repeated in this connection that 15 ft. is the largest diameter that can be given to the Pachuca tank, while the diameter of the Parral tank may be made as great and the height as low as desirable.

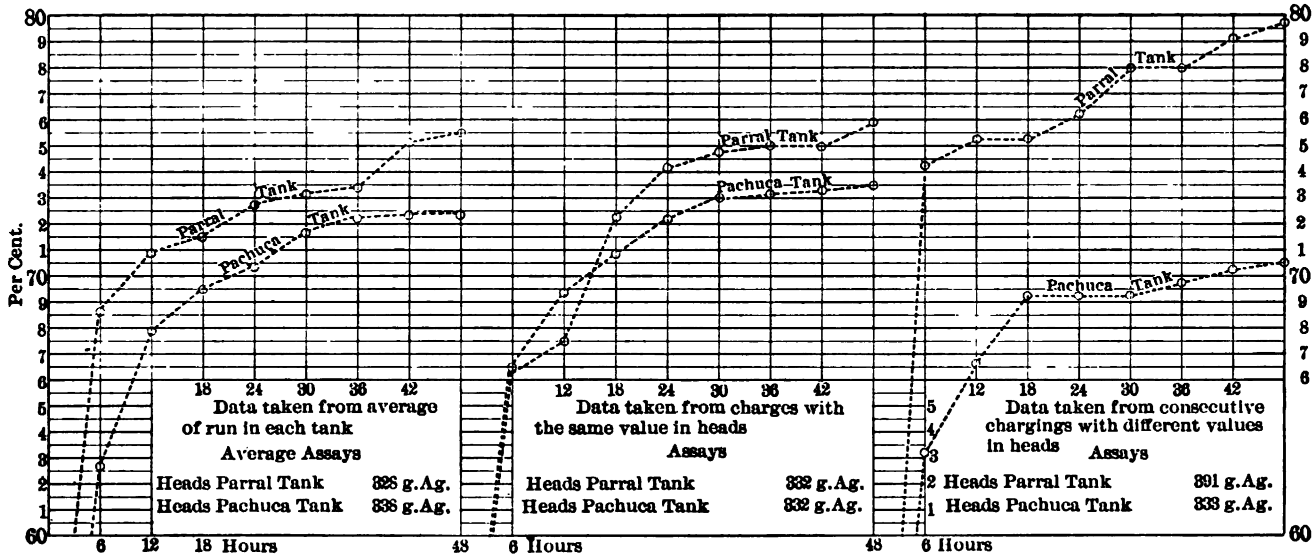
TABLE II.—*Comparative Dimensions of the Parral and Pachuca Tanks and Their Respective Equipment, as Installed at the Mill of the Veta Colorado M. & S. Co.*

Points of Comparison.	Dimensions or Number. Pachuca.	Parral.
Height in feet,	45	42
Diameter in feet,	15	25
Area of bottom of tanks in sq. ft.,	176.7	490.8
Holding-capacity for each foot in height, cu. ft.,	176.7	490.8
Number of air-lift or transfer-pipes,	1	4
Diameter of each air-lift pipe in inches,	16	12
Total cross-sectional area of air-lift pipes, sq. in.,	201	452
Diameter of each compressed-air pipe in lift-pipes,	1.5	1
Total cross-sectional areas of air-pipes in lift-tubes,	1.7671	3.1416
Proportional area of tank-bottom for each sq. in. of cross-section of air-lift tubes, sq. ft.,	0.8	1.8
Area of tank-bottom for each sq. in. of compressed-air pipe, sq. ft.,	100	156

This table shows, especially if studied in connection with Table I., that, taking unit against unit in tank-construction and equipment, the Parral tank is the more economical.

Extraction of Values.

An unexpected result became manifest in plotting the time-extraction curves, Fig. 11, from the assay-records of the samples taken, during the treatment-operations, from the Parral and Pachuca tanks when operating on the individual-charge method. The curves show parallel results obtained from the two tanks treating similar pulp under three different conditions.



Chemical Constituents of Solution.

KCN, ... 15 per cent.
Protective alkalinity, . . 850 g.
Lead, ... 3 g.

Physical Condition of Pulp.

Dilution, ... 2 to 1
Specific gravity, ... 1.26
Screen sizes :
+ 200, 15 to 20 per cent.
— 200, 75 to 80 per cent.

Extraction.

Prior to tank treatment, 10 to 20 per cent.
After treatment, as per chart.
Total extraction, as per chart + 10 to 20 per cent.

Note.—In explanation of the percentage column of the above chart, it may be said that more than 62 per cent. of the head-values were extracted during the first six hours' agitation.

Fig. 11.—Extraction-Curves Plotted from Records of Operations in Pachuca and Parral Tanks. Samples Taken Every Six Hours and Assayed.

Conclusion.

This paper is presented as the announcement of a new and improved system of slime-pulp agitation, for the consideration and criticism of metallurgical engineers connected with or interested in cyanidation. I have given much thought and study to the working out of the design and the development of its mechanical details, and have had the pleasure of seeing my labors rewarded by complete success.

I wish to extend my thanks to William Thompson and Frank Reichmann, the superintendent and engineer of the milling-operations, respectively, who compiled the details of the operations and made the drawings submitted with this paper.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Examination of Dredging-Properties.

BY FRANCIS J. DENNIS, SAN FRANCISCO, CAL.

(San Francisco Meeting, October, 1911.)

MANY factors govern the value of dredging-ground, and much capital can be wasted by the mistaken policy of contracting for the purchase of property and the installation of machinery before a thorough examination has been made. To the uninitiated investor the presence of gold is generally the criterion, and very superficial evidence is necessary to satisfy him as to this point. He considers the comprehensive report of a competent engineer as a wasteful extravagance and cannot understand why the engineer requires so much time and money to ascertain the information on which to base his conclusions, when the promoter can furnish him such pleasing and satisfactory data with but little expenditure of time and money. The uninitiated investor will often optimistically risk capital for purchase and equipment, and not until the venture comes to grief does he learn that the conditions are wholly unsuited for dredging. In many instances, a short preliminary examination by a competent engineer would have disclosed these facts. The mere presence of gold is by no means sufficient; some of the other factors necessary to be ascertained in determining the value of placer-ground for dredging-purposes are: (1) character and distribution of gold, and how much can economically be recovered; (2) character of bedding underlying the gravel, its contour, and whether its gold can be recovered by ordinary dredging-operations; (3) area and depths of gravel, surface contour, over-burden, water-level, proportion of fine material and boulders, and the presence of any material which might interfere with the dredging-operations and the recovery of the gold; (4) water-supply, power available, labor, transportation, and supplies, and cost of these; (5) climatic conditions; (6) title to property, cost and royalties, and legal obstacles to carrying on dredging-operations.

A brief reconnaissance may be sufficient to determine that some of the essential conditions for successful dredging are

lacking and no further expense need be incurred. Exposures in the gullies, pits, and shafts often afford considerable evidence of the extent and characteristics of the gravel and the contour and character of the bedding, and this may be readily supplemented by sinking a few additional shafts or drilling a few holes. The preliminary report proving satisfactory, arrangements should be made for thoroughly testing the ground. The area should be surveyed, and the shafts or drill-holes placed according to the sampling-scheme adopted. Information obtained during the preliminary examination should be of use in forming this plan. Where the deposit of gravel and occurrence of gold are fairly regular throughout the area, it is generally laid out into squares of from 200 to 500 ft. Where the occurrence is in channels, this method cannot be pursued, and more judgment and ingenuity are called for in placing the holes and in making estimates from the results obtained. Holes may be placed at short intervals across the channels in rows at regular intervals, and it is sometimes the practice to arrange the holes so that those of alternate transverse lines form longitudinal lines. Whether shafts shall be sunk or holes drilled is a question of expediency. Shafts afford the most complete information, and where round shafts can be cheaply sunk, this method is advisable. Where expensively timbered shafts are required and water and other features militate against shaft-sinking, the cost is prohibitive and drilling is resorted to. It is by this latter method that most of the dredging-ground in California has been prospected, but it must be borne in mind that the prospectors previously had considerable information as to the characteristics of the gravel and bedding.

No. 3 Keystone drills are usually used in making drilling-tests, but as the plant is heavy and somewhat difficult to transport, the development of the hand-drill in recent years has made it an important factor in the prospecting of gravel-areas in foreign countries, or in localities difficult of access where the transportation-charges are high. Its low first-cost—about one-half of that of a steam-drill—the great reduction in weight—about one-tenth of a non-traction or one-fifteenth of a traction-drill, exclusive of supplies—and the further fact that the whole hand-drill outfit, weighing a little more than 1,000 lb., can be made up into packs, with a maximum weight of less than 75 lb.

each, is of considerable importance in prospecting. A complete and very interesting article on the Empire hand-drill for prospecting-work has been published by J. Power Hutchins and Norman Stines.[1] In new territory it is advisable, even though expensive, to sink a few shafts in the initial stages of the investigation, and the data thus obtained will enable a closer interpretation of the character of the ground passed through in drilling.

It is not intended that this present paper shall discuss the details of drilling- and sampling-operations, types of drills, and methods of determining the gold-content of samples. But it should be borne in mind that reliable, experienced men should be employed in this work, and that constant vigilance should be exercised. Field- and time-books should be conscientiously kept, assay-values at various depths noted, characteristics of the bedding and gravel, time consumed, difficulties encountered, and features that might militate against dredging recorded. These data should be recorded in the prospecting log-book, which at the finish should contain a summary of all data obtained during the progress of the drilling. From this the engineer should then allocate the results to the proper area, eliminate unprofitable areas where practicable, and summarize the yardage and value of the area that should be worked. In making this estimate there is no fixed formula for discounting the results indicated by the drilling-test, but experience has shown that the amount of gold obtained by dredging is generally only from 75 to 80 per cent. of that indicated by prospecting. Having ascertained that the conditions are favorable for dredging, it is then incumbent on the engineer to determine on the type and size of dredges, the number to be installed, and the general campaign to be followed.

Having a given area, the yardage and contents of which can be estimated with considerable certainty, he is called upon to decide what equipment will yield the best economic results. His information of the physical characteristics of the area, together with his general knowledge of what is being accomplished in other fields, should enable him to estimate closely operating-costs with dredges of various capacities and construc-

[1] *Mining and Scientific Press*, vol. cii., Nos. 1 and 4, pp. 39 and 164 (Jan. 7 and 28, 1911).

tion. A small yardage will evidently not justify a large and expensively-constructed dredge, nor would the extra expense of construction necessary in a dredge for heavy ground be justified in constructing a dredge to work a similar yardage of lighter ground. Amortization of the cost of equipment should be set off against operating-costs, and no extra expenditure be incurred that will not be justified by a corresponding reduction in operating-costs. For example, assume an area of 100 acres of gravel, 11 yd. deep, and containing 5,000,000 cu. yd. A 13.5-ft. boat would cost about $250,000 and would work out the area in less than two years. Assume the operating-cost to be 4 cents per yard, the amortization of the equipment would be 5 cents per yard, making a total of 9 cents per yard. A 5-ft. boat would cost about $85,000 and would work out the area in about five years. Assume the operating-cost to be 6 cents, the amortization of the equipment would be 1.7 cents, a total of 7.7 cents per cubic yard. The installation of the smaller capacity boat would be clearly advisable. Assume the acreage to be 300 and the yardage 15,000,000. The operating-cost of the large boat would be 4 cents and the amortization 1.666 cents, a total of 5.666 cents per yard. Two 5-ft. boats at a total cost of $170,000 would be required to handle this yardage. The operating-costs would be 6 cents and the amortization 1.133 cents, a total of 7.133 cents per cubic yard. Here the installation of the larger boat is clearly advisable. It is not thought necessary to enter into the refinements of interest calculations in the above examples, but where the operating-profits are large, this factor is well worthy of consideration.

The value of the plant as an asset after the area has been exhausted should also be taken into consideration. The engineer is, of course, presumed to have taken cognizance of, and provided for, the amortization of the initial investment in presenting his report to his principals. Moreover, he may have been sent to report on the area as a dredging undertaking, and, although he finds that it is not suitable for simple dredging alone, some modified form or some method which is an outgrowth of the industry may be profitably undertaken. It is incumbent upon the engineer to use the greatest care in ascertaining information about the property, and the greater his ability and experience the more valuable will his report be to his principals.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Laws of Igneous Emanation Pressure.

BY BLAMEY STEVENS, NEW YORK, N. Y.

(San Francisco Meeting, October, 1911.)

IN this paper, which is a logical extension of my paper, The Laws of Intrusion,[1] the various pressures of emanation and their mechanical causes and effects on the large scale of nature are determined, and a classification of emanations is deduced therefrom.

The Subterranean Sea.

The subterranean sea is here defined as the intercommunicating water contained in the trains of pores and fissures of the rocks down to great depths. Whether the actual amount of water constituting this subterranean sea be large or small, does not enter into the present argument, since the static pressure of this water at any particular depth is not a function of the quantity: it involves only the depth and the density of the water.

Densities.

The total pressure at depths down to 10 or 15 miles is made up of the rock-stresses investigated in my previous papers, and the pressure of the subterranean sea. The latter component must evidently be equal to the weight of a solid column of the overlying water of unit sectional area. As water expands with heat, it should really be necessary to sum the density at every level. A knowledge of the densities of water under a variety of conditions is therefore needed, but does not seem ever to have been ascertained for such combined pressures and temperatures as we have to consider.

The specific gravity of water at 28° C. for various pressures up to 400 atmospheres, has been determined by Barus,[2] who

[1] *Trans.*, xli., 650 (1911).

[2] *American Journal of Science*, Third Series, vol. xli., No. 242, p. 110 (Feb., 1891).

tried also to obtain results for higher temperatures, but was foiled in this attempt by the circumstance that the hot water rapidly dissolved the glass of the capillary tubes in which his experiments were conducted. No other systematic attempt seems to have been made since.

The specific gravity of water at 365° C. and 200 atmospheres (the critical temperature and pressure) has been determined as 0.429. At the normal temperature-increase of 1° C. per 100 ft. of depth, the above temperature corresponds to about 6.5 miles of depth; but the pressure would be obtained in the first 1.25 miles. It is impossible to say, without experimental research, to what extent the expanded water at specific gravity of 0.429 would be compressed by a pressure of more than five times the critical pressure. The judgment of nine out of ten scientists would, however, probably place the increased specific gravity somewhere near unity, *i.e.*, equivalent to the maximum gravity under surface-conditions. There are several reasons for this conclusion, but they will not be discussed in this paper. We shall adopt this figure as a tentative one for all depths.

We can with much more certainty assume a constant value for the specific gravity of rocks. We know that with the temperatures and pressures considered, this does not alter much. The volumetric expansion for a difference of temperature of 100° C. is only 0.0017 for marble, and 0.0024 for granite, while the volumetric compression is about the same for the corresponding head of 10,000 feet.

Pressures of Igneous Magnas.

According to my paper, The Laws of Intrusion, the pressure of an igneous magma is equal to the sum of the rock-pressure, its cohesive stress, and the pressure of the subterranean sea.

In order to arrive at a numerical measure of these pressures, let D be the density of the rock, and d that of the water. Taking H to be the depth, or head, and C the cohesive stress of the rock if broken by the magma, the total vertical magma-stress will be approximately DH + C. For equi-pressure country the horizontal stress is also DH + C, which is the magma-pressure of an irregular dike, sill, or laccolith. Except

under rare conditions, it is the maximum intrusive pressure possible.

In fissuring country DH remains the vertical pressure. Of this pressure the part dH is the pressure of the water, and the remainder (D — d)H must show the stress of the rock.

It has been shown [3] that the horizontal rock-head in fissuring country is given by $\frac{H}{I}$, where $I = \frac{1 + \sin \phi}{1 - \sin \phi}$, in which equation ϕ is the angle of the slip, $\tan \phi$ being the coefficient of friction. The horizontal rock-pressure is therefore $(D - d)\frac{H}{I}$, and adding the water-pressure, the total horizontal pressure is $(D - d)\frac{H}{I} + dH$. This is the minimum magma-pressure possible.

Assuming the mean specific gravity of the rock to be 2.7, and the maximum value of I to be 5, the minimum pressure is approximately $\frac{DH}{2}$, or less than half of the maximum pressure.

Exhalations.

We may assume that, as molten magma rises, it frees itself more and more from occluded gases. These form what we may term "exhalations." Although they inevitably emanate first as gases, it must be apparent that after they leave the magma they are often cooled to the normal temperature of the surrounding rocks and mixed with the meteoric waters.

Residues.

If some of the occluded gases are still retained under external pressure while the magma is molten, they may be forcibly expelled from the magma as it consolidates. These may be termed "residual emanations" or "residues," since they form during the last stage of vulcanism and are left after the main magma-mass has consolidated.

Dry Magmas.

When all the water in a magma has been exhaled it may be called dry. In this condition it still contains the remainder of those soluble substances which are not exhaled but might have

[3] The Laws of Fissures, *Trans.*, xl., 475 (1910). This particular formula for I may be easily deduced from those given.

been residues had any water been left for their solution. These may include the uncombined forms of gold, silver, copper, etc. The Lake Superior copper-deposits are possible examples. It has never been shown, however, that the whole of the sulphur in copper-bearing magma could be exhaled.

Intrusive Emanation.

An intrusive emanation may be defined as one which breaks a way for itself in the rocks which it traverses. It thus resembles in many respects an intrusion of magma (see Figs. 3, 4, 5, 6, 7, 8, and 10). In Figs. 4, 6, and 10 the emanation is considered to have opened the fissures, dikes, and sills, and wholly or partly deposited its minerals, before the magma which afterwards filled some of these cavities had reached them.

Free Emanation.

A free emanation may be defined as one which exists in some cavity, crevice or other opening which has been formed previous to the intrusion of magma from which the emanation is derived. Most fissure-veins are of this type (see Figs. 13 and 14).

Pressure of Exhalation.

The pressure of exhalation at the point of emanation is essentially that of the magmas. This pressure has been found above and need not be here repeated.

Effective Exhalation-Pressure.

The pressure which is effective in producing a flow of exhalation through the fissures and cavities of the rocks, is the difference between the exhalation-pressure and that of the subterranean sea, statically considered, for the same depth. The effective pressures at the points of emanation are therefore:

$$(D - d)\,H + C \quad \text{(For equi-pressure country).}$$

$$(D - d)\,\frac{H}{I} \quad \text{(For fissuring country).}$$

These, it will be noticed, are the total rock-stresses—a result which might have been foreseen. In terms of water-head, these stresses are:

$$1.7\,H + C \quad \text{(For equi-pressure country).}$$

$$0.34\,H \quad \text{(For fissuring country).}$$

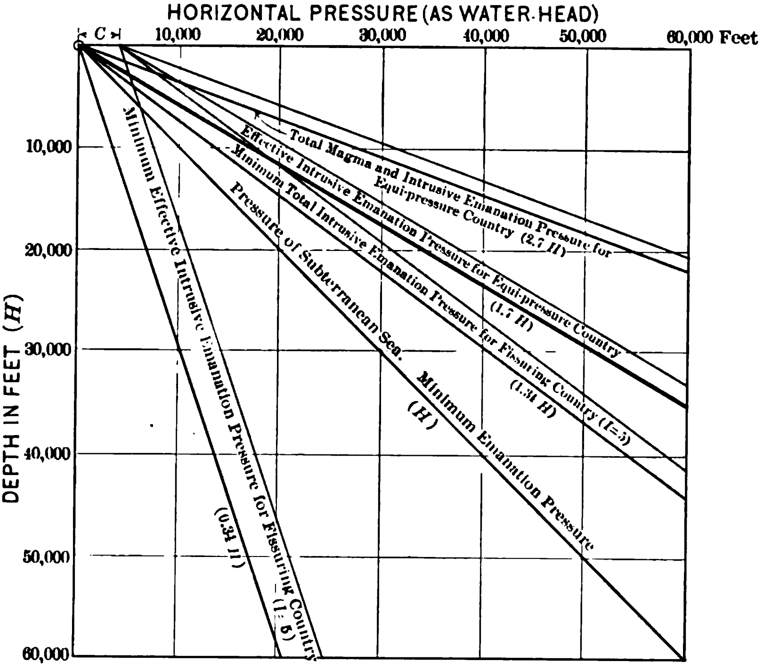


FIG. 1.—DIAGRAM SHOWING VARIOUS LAWS WHICH GOVERN EMANATION-PRESSURE.

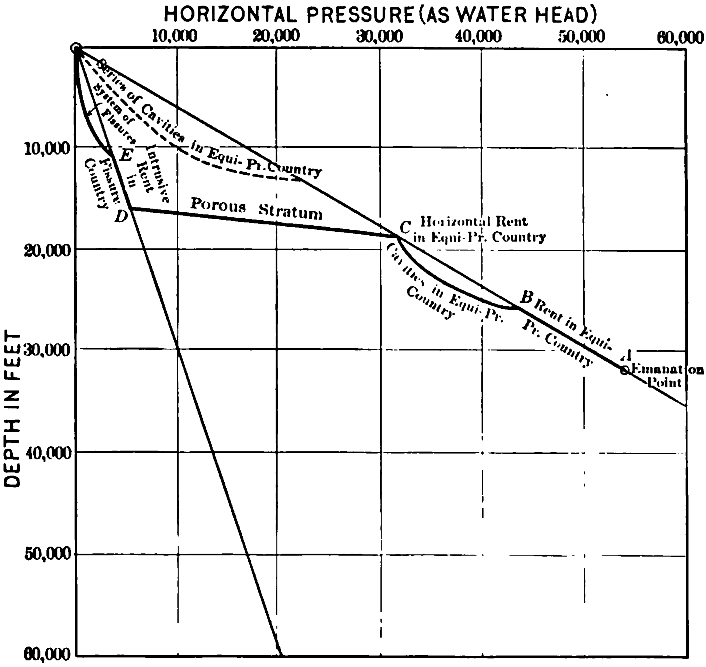


FIG. 2.—DIAGRAM SHOWING EXAMPLES OF HYDRAULIC GRADIENTS OF EMANATIONS.

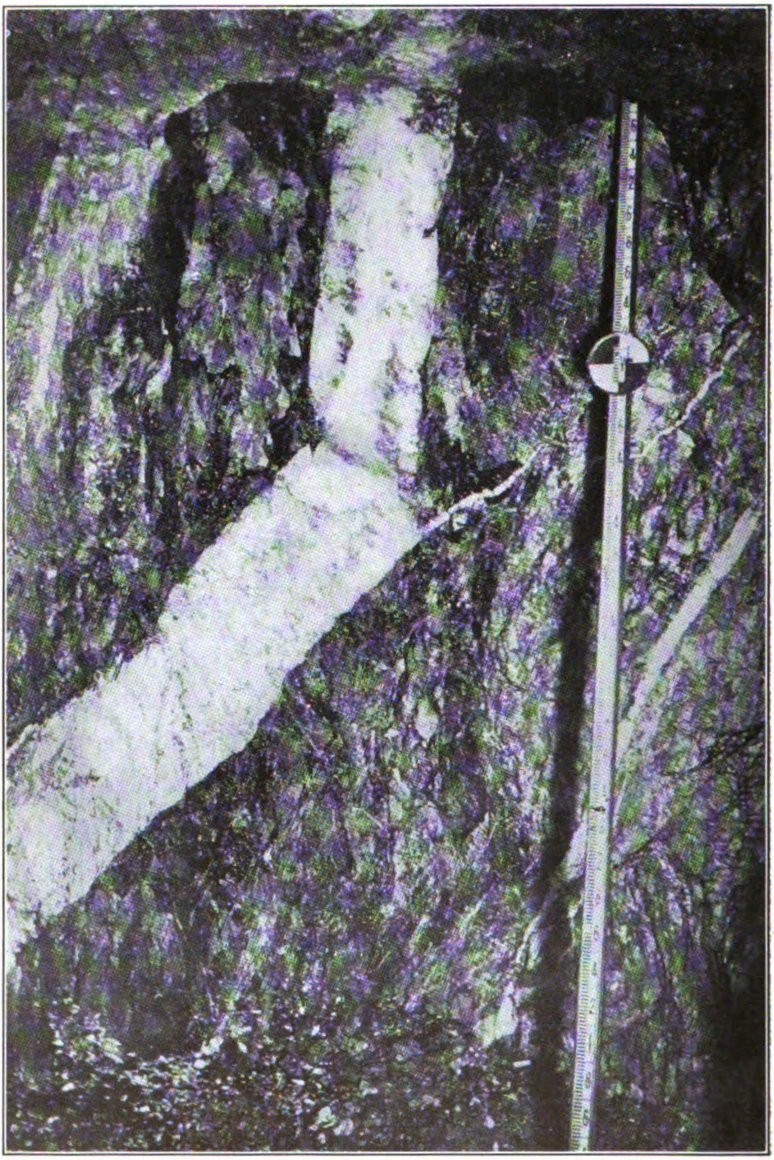


FIG. 3.—QUARTZ DIKE, AURORA, ALASKA.
(From a photograph by the author.)

Fig. 1 shows the total heads and the effective intrusive hydraulic heads for equi-pressure country, assuming C as 4,000 ft. It shows also the minimum heads for fissuring country which is being intruded. The common effective head (1.7 H) applies to fissures, joints, and cleavage in equi-pressure country which is being intruded. This is called common and accentuated with a very thick line, because it represents a very usual condition of emanations.

Pressures and Effective Pressures of Residues.

The pressures and effective pressures of residues are limited by the rock-stresses; for we have reason to believe that expansion takes place on the final separation of the magma and residue. The maximum pressures and effective pressures are therefore the same as for exhalations. The minimum pressure is that of the subterranean sea, and the minimum effective pressure is *nil.*

Regional Pressures.

A system of fissures and cavities may become filled with liquid at a pressure approaching that of emanation. The porous rocks which are included in and surrounded by such a system are not subjected to any difference of pressure tending to cause flow within the pores. The deposition of mineral is therefore confined to the fissures and cavities. The mode of deposition is very different with a forced capillary flow of emanation, for in this case the pressures are not distributed over a region, but fall very rapidly.

Intrusive Emanation-Zones.

There is a good deal of difference between the intrusion of emanations and the intrusion of magmas. As we have seen, with emanations the common effective pressure is (D — d)H, and with magmas it is the whole pressure DH. The reason is that the emanation forms part of the subterranean sea, whereas, the magma does not. The pressure of the water in the rocks immediately surrounding an emanation rises and falls with the pressure of the emanation, whereas, the pressure of an intrusive magma is not so intimately connected with the water-pressure.

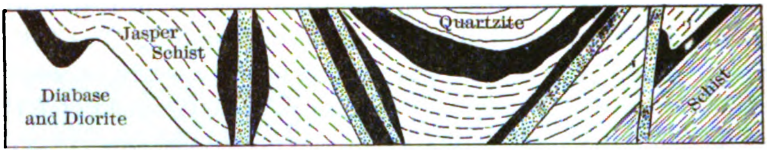


FIG. 4.—DIAGRAM SHOWING OCCURRENCE OF IRON-ORE WITH DIKES OF DECOMPOSED DIABASE AND DIORITE, MARQUETTE, MICH.

After Van Hise, Monograph XXVIII., *U. S. Geological Survey* (1897).

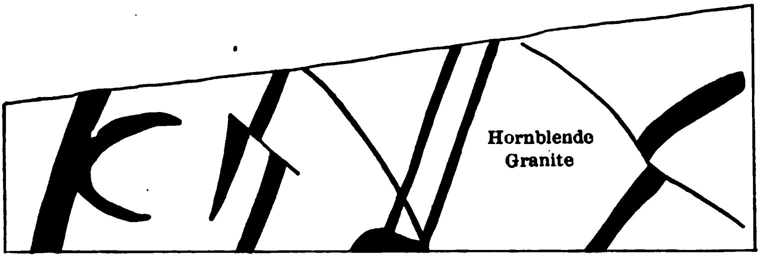


FIG. 5.—INTRUSIVE TIN-BEARING PEGMATITE "VEINS" IN HORNBLENDE-GRANITE NEAR OSHOEK, SOUTH AFRICA.

After W. R. Rumbold, *Trans.*, xxxix., 787 (1909).

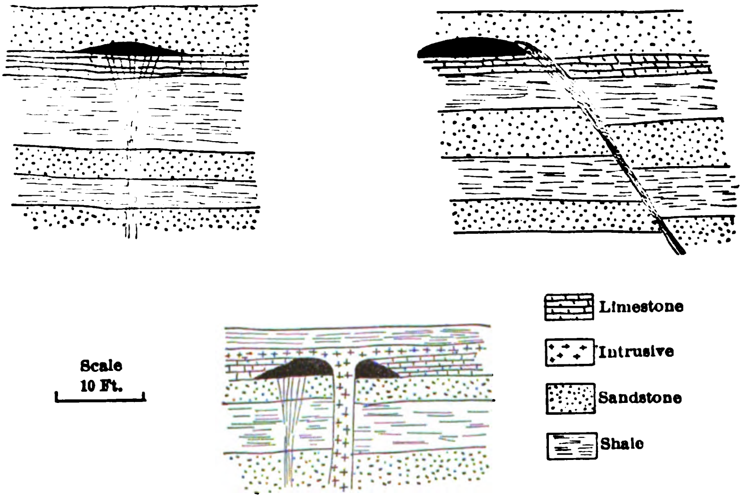


FIG. 6.—SILVER-GOLD INTRUSIVE EMANATION-DEPOSITS NEAR RICO, COLO.

After J. B. Farish, *Proceedings of the Colorado Scientific Society*, vol. iv., p. 164 (1892–93).

With the magma the rending-pressure is applied at one particular edge and the rending goes on along a definite plane. With the emanation, it is applied over a zone which may contain many slips, joints, and cleavage-planes, any or all of which may open up to some extent. This zone may be limited by physical conditions, such as the walls of a stronger or more impervious rock, or one with the cleavage in a different direction, or from many other causes. The zone affected may often take the form illustrated in Fig. 9, taken from the Juneau gold-belt of southeastern Alaska.

Quartz dikes may sometimes be found where harder or more compact rocks are encountered, *e. g.*, that shown in Fig. 3, from southern Alaska. The Leadville exhalations (Fig. 10) are partly intrusive; and the Independence mine of Cripple Creek (Fig. 7) is a fine example of intrusive emanation.

Subterranean Lakes.

Subterranean lakes may be defined as bodies of stagnant water isolated from the subterranean sea by impervious rocks.

Such lakes are common, become more frequent with depth, and may contain considerable saline matter. This may have been derived from the ocean or a salt lake at the time of deposition of the rock, by subsequent circulation of saline waters, by solution of saline deposits, from emanations, or by some combination of these sources.

The pressure of subterranean lakes is never below that of the subterranean sea, and is usually greater. This circumstance may be explained either by its connection with a source of igneous emanation or by the heating of the imprisoned waters above their original temperature. In the great majority of cases, however, it is doubtless due mainly to the slow squeezing of the containing rocks, either horizontally or vertically, so as to diminish the pore-space.

The limit to the pressures obtained is fixed by the breaking of the impervious boundary of the lake. The water-pressure required for this is the same as for an emanation. This similarity may sometimes make it hard to tell whether some intrusive solutions are of igneous origin or come from subterranean lakes, which have been subjected to stress. The absence of volcanic rocks may, however, be a fair criterion. Examples are

the lead- and zinc-deposits of the Mississippi valley and the massive salt deposits[4] of the Louisiana coast. These deposits occur in horizontally-stratified rocks which are pushed up around

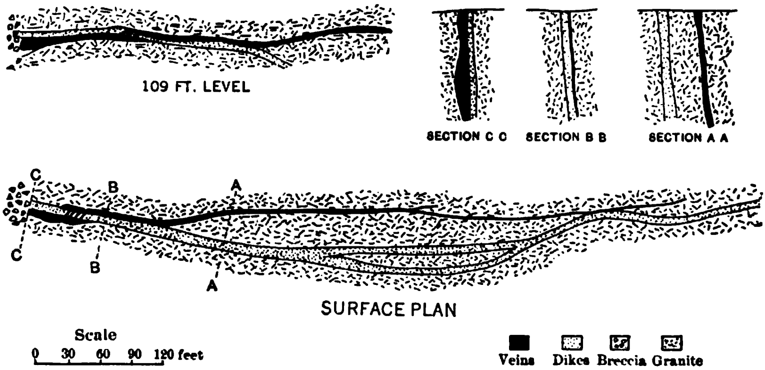


FIG. 7.—INDEPENDENCE MINE, CRIPPLE CREEK, COLO.
After R. A. F. Penrose, Jr., *Sixteenth Annual Report, U. S. Geological Survey*, Part II., p. 200 (1894–95).

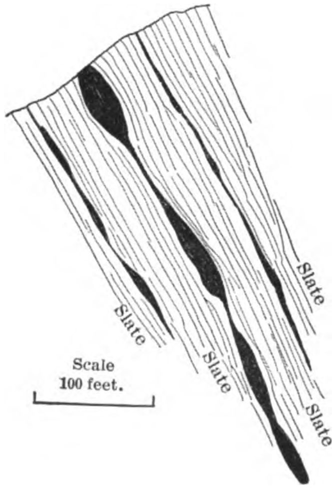


FIG. 8.—PYRITE-DEPOSITS OF VARALDSO, NORWAY.
After Vogt.

the edges of the deposit. In both cases the pressures concerned are evidently of intrusive magnitude.

[4] *Bulletin Nos.* 5 and 7, *Geological Survey of Louisiana* (1907, 1908).

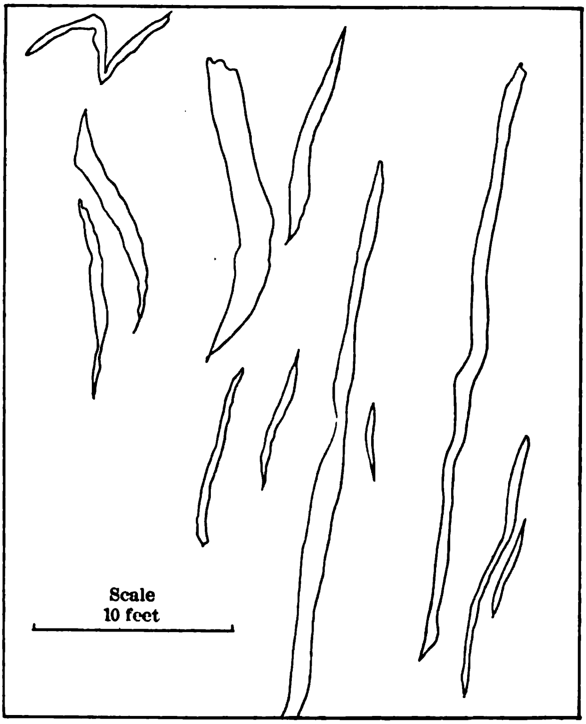


FIG. 9.—INTRUSIVE RESIDUAL GOLD-QUARTZ IN BROWN DIORITE, JUNEAU, ALASKA.

After Spencer, *Bulletin No.* 287, *U. S. Geological Survey* (1906).

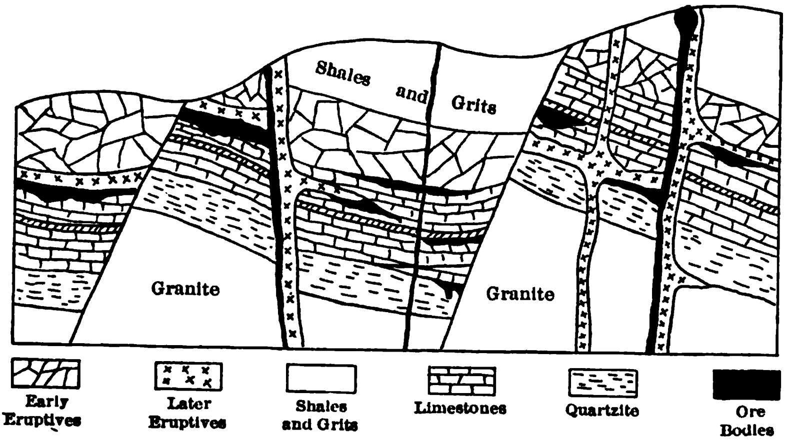


FIG. 10.—IDEAL SECTION OF BREECE HILL, LEADVILLE, COLO.

After Max Boehmer, *Trans.*, xli., 165 (1911).

Intrusive Residues.

There is strong evidence that residues may have a pressure high enough to form intrusions. I shall show in a later paper that they are the only ones which can contain large quantities of silica when they leave the magma. Intrusive dikes and lenses of quartz, etc., will therefore point to the intrusive pressures of residues. (See Figs. 3, 5, and 9.)

Explosive Emanations.

There are cases where intrusive rents are formed of such size that the emanations rapidly escape to the surface. They then lose little heat and expand freely, and so rapidly that the condensing water has no time to fill the rent. The effective pressures become equal to the whole pressure at the point of emanation, and may in some cases be so suddenly released to the atmosphere, or at comparatively small depths, that what we term a volcanic explosion takes place.

Flow of Igneous Emanations.

If the flow of emanations from magma goes towards the surface of the earth in a single straight path, with similar conditions along its entire length, the straight lines of Fig. 2 may be considered as the mean hydraulic gradients. The effective pressure at every place in the path of flow is then just equal to the rock-stresses. Any additional stress would further open the crevices of the rock. If, however, as must generally be the case, the flow covers a greater area, and encounters fewer obstacles, as it gets nearer the surface, the pressure-curves will be somewhat as represented by the dotted line in Fig. 2. The pressures at the two terminals remain the same, but the variation of pressure with depth decreases as the emanation gets nearer the surface. The dotted line shows the effective pressure to be less than the prevalent rock-stresses for the corresponding depth.

On the other hand, it is conceivable that a less porous stratum or bar of unfissured rock might be encountered between the source of emanation and the surface. At such places, the effective pressure would become greater than the corresponding rock-stresses, and the impervious rock would

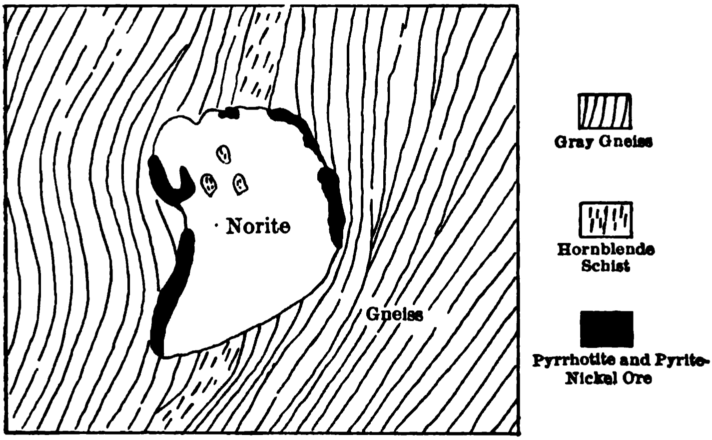


FIG. 11.—SKETCH-MAP OF MEINKJAR PYRRHOTITE- AND PYRITE-NICKEL FIELD.

After Vogt. *Zeitschrift für praktische Geologie*, vol. i. (1893). See *Nature of Ore-Deposits*, by Beck and Weed.

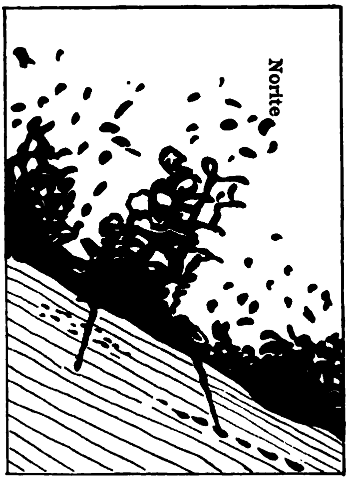


FIG. 12.—ENLARGED SECTION OF A PART OF NORITE-CONTACT SHOWN IN FIG. 11.

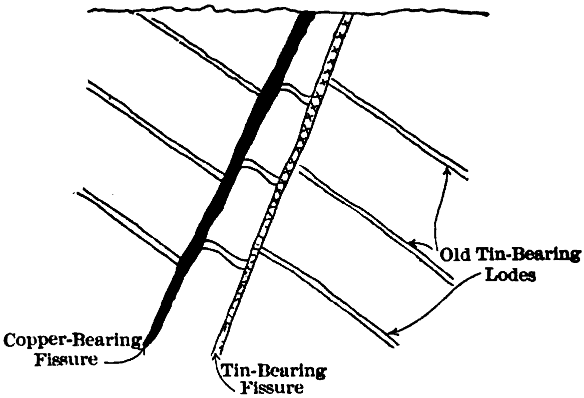


FIG. 13.—SECTION OF SEAHOLE MINE, CORNWALL, ENGLAND.

After Carne. See *Geology*, Prestwich, vol. i., p. 318 (1886).

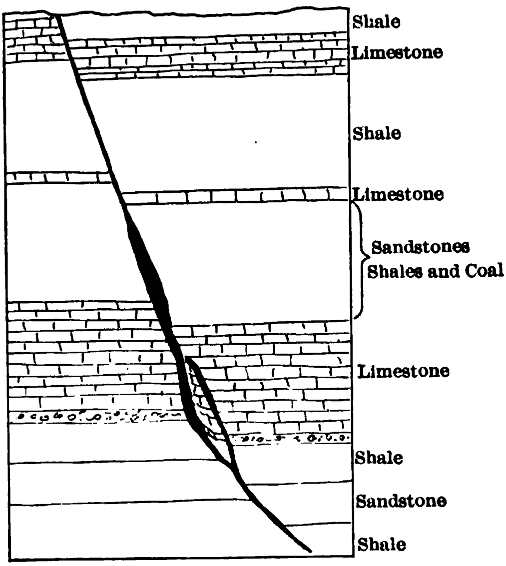


FIG. 14.—SECTION OF A LEAD-VEIN, ALSTON MOOR, CUMBERLAND, ENGLAND.

After Wallace. See *Geology*, Prestwich, vol. i., p. 320 (1886).

rupture, until conditions of equilibrium were again established by the rending of channels of sufficient size.

The heavy lines of Fig. 2 illustrate a hypothetical case. Starting at *A*, the point of emanation, the intrusive pressure rends a path or series of paths for itself until it reaches *B*. There the emanation finds a series of previously-formed cavities and travels by them until it reaches *C*, which is the under side of a porous bed, where the cavities cease or are choked. The emanation then rends a horizontal path for itself along the bedding and thereby exposes enough area of porous material to permit it to flow upward through the bed, with rapid loss of pressure, to *D*, the lowest part of the country affected by normal fissuring-pressure. It has, however, to rend its way to *E*, before it strikes the series of normal fissures by which it finally reaches the surface at 0.

The lead- and zinc-deposits of the Mississippi valley are probably good examples of discontinuous rupture.[5] W. P. Jenney, who examined this field for the U. S. Geological Survey, says that, although not associated with visible intrusions of igneous rocks, all the lead- or lead-and-zinc regions of the Mississippi valley occur along three lines of upheaval, and that the vertical fissures are the channels through which the mineral-bearing solutions have entered the rocks. These so-called fissures have in most cases been almost completely closed again; and the absence of displacement has been the chief argument against their having been carriers of mineralizing solutions.

Capillary Flow.

Capillary flow often starts from the point of emanation. This takes place at an igneous contact where there is no other means of egress for emanation (see Figs. 11 and 12).

In other cases the emanation may be conveyed to the porous medium by a fissure or intrusive rent (see Figs. 6 and 10). A number of lead- and zinc-deposits come under this head. Usually the porous medium serves to distribute the hydraulic pressure over a larger area, so that no further fissures or rents are required to convey it. The porous material also greatly reduces the effective pressure and robs the contents of every

[5] *Trans.*, xxii., 171 (1893).

mineral which can possibly be replaced under existing conditions of pressure and temperature. The effective emanation-pressure within a few inches or feet of the magma may under particular circumstances be *nil.*

Classification of Emanations.

A classification of emanations is given in Table I. This table is constructed on the same plan as that proposed for fissures and intrusions in my previous papers; that is to say, an emanation of either class may be of either type, and each type of class may have either form of flow, so that there are eight different divisions, into one of which an emanation may fall. This, be it remembered, is without considering the change in character of the emanation after it leaves the magma. The class is fixed from the derivation, and not the actual condition of the emanation at the time of mineral deposition. Of the eight divisions, there are only six which need be considered, the intrusive capillary combinations being rare and unimportant.

It must be again noted that the question whether the ore-bearing fluid is gaseous or liquid at the time and place of deposition does not enter into the present discussion, which considers, first, the conditions at the time and place of emanation; secondly, the pressure at the time and place of deposition, and, lastly, the rate of change of pressure at the time and place of deposition. These leave their marks respectively on the deposit: first, in its chemical constitution; secondly, in the shape and position of the cavity filled; and lastly, in the size of the cavity.

TABLE I.—*Classification of Emanations.*

	Class.	Derived from.	*Type.*	Cavity.	Effective Pressure.	*Flow.*	Size of Channel or Cavity.	Rate of Variation of Effective Pressure.
Igneous Emanations. (Gases and liquids expelled from igneous magmas.)	*Exhalations*...	Liquid magmas.	*Free*....	Not ruptured or opened by emanation-pressure.	Less than least rock-stress.	*Capillary*......	Small.	Rapid.
	Residues......	Solidified magmas.	*Intrusive*......	Rent or ruptured by emanation-pressure.	Greater than least rock-stress	*Super-Capillary*......	Large.	Slow.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Physical Data of Igneous Emanation.

BY BLAMEY STEVENS, NEW YORK, N. Y.

(San Francisco Meeting, October, 1911.)

MY previous paper is entitled, The Laws of Igneous Emanation Pressure. The present paper lays no claim to the exactitude and completeness of a law, since it is of a provisional nature and may be disregarded when experiments have established a basis for more exact reasoning.

The general physical states in which aqueous emanations may occur are first considered. The possible physical conditions under which the mineral elements may occur in emanations are then discussed, and a classification of deposits, dependent on emanation, is proposed.

A system of scientific experimental investigation is outlined, and it is shown that the physical and chemical properties of emanation may be exactly determined thereby. The investigation is urged as feasible and simple, and not necessarily requiring large and costly apparatus. It is the only step necessary to make possible the formulation of a complete set of laws of igneous emanation.

Process of Emanation.

In a rising column, magma ranges in temperature from 900° to 1,200°C. Exhalation must begin at some fairly great depth. What this depth may be we can only surmise, since no experimental evidence is available. Exhalation, however, continues as the magma flows upward, until at another level the occluded gases have all escaped. This depth is probably upward of 5,000 ft. (See Fig. 1.)

All exhalations must come from between these two levels. As the whole emanation is the sum of the exhalations and residues, the residues must come from below the uppermost level. They will be most abundant when coming from those parts of the intrusion which have solidified below the lower level.

Conditions at Time of Emanations.

The physical and chemical conditions of emanation are as yet little known. Barus[1] has shown that colloidal silica is miscible in all proportions with water, at all temperatures and pressures at which water can exist as a liquid. It seems, however, certain that the universal tendency is for the colloidal to

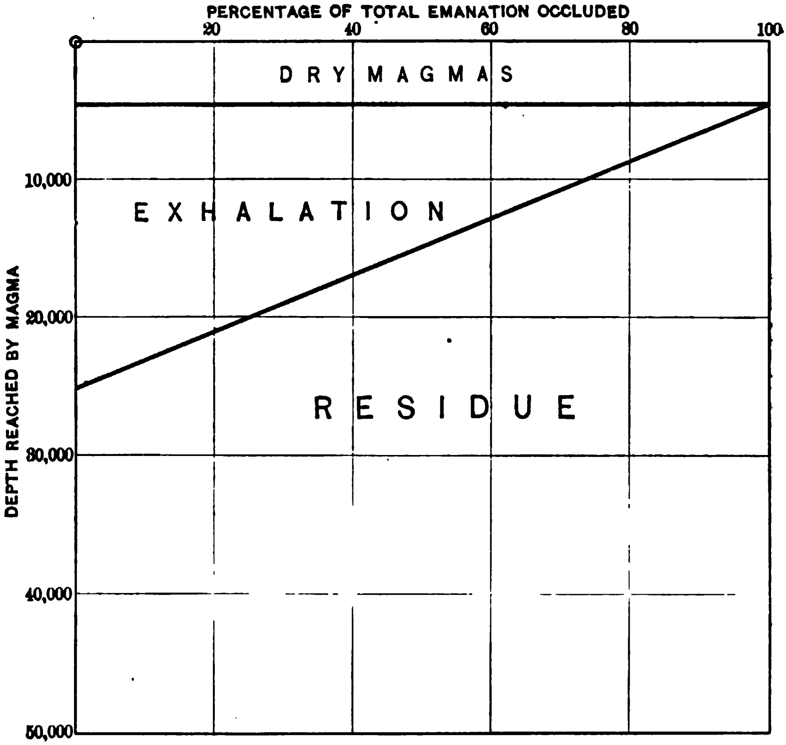


FIG. 1.—DIAGRAM SHOWING RELATIONS OF THE TOTAL EXHALATIONS AND RESIDUES OCCLUDED FROM A MAGMA WHEN IT HAS REACHED VARIOUS DEPTHS. (Actual depths of percentages are merely speculative guesses, for an average magma, there being no experimental data.)

assume the crystalline form; and no solution of crystalline silica has ever been made in pure water. Barus tried, unsuccessfully, up to 600°C.,[2] the rock and water being heated in iron

[1] *American Journal of Science*, Fourth Series, vol. vi., No. 33, p. 270 (Sept., 1898). See also C. R. Van Hise, *Sixteenth Annual Report, U. S. Geological Survey*, pt. I., p. 687 (1894–95). In this publication Van Hise first states this important principle. Barus (*ibid.*) states that the melting-point of aqueo-igneous silica frequently lies below 200° C.

[2] *Fourteenth Annual Report, U. S. Geological Survey*, pt. I., pp. 161–162 (1892–93).

tubes capable of withstanding great pressure. As liquid magma contains colloid silica, there can be little doubt that water will mix with it, if the pressure is great enough to retain the water in a moderately dense fluid form at these great temperatures. There is, however, evidently a limit to the miscibility of steam and magma.

Miscibility of Liquids.

It must be conceded that molten silicates are as completely miscible in depth as on the surface of the earth. The general trend of physico-chemical theory and experience leaves little doubt of this fact, and no forcible evidence to the contrary has been discovered.

There are also good grounds for the presumption, stated above, that liquid silicates are completely miscible with liquid water.

Distinction Between Liquids and Gases.

Above the critical temperature, there is no sudden change of density separating the liquid and the gaseous forms of matter. The same change of properties must take place, however, though it may not be at any well-defined temperature.

The distinction between liquid and gaseous conditions may be determined from one or more of these changes of property; for example, all exhalations are presumably gaseous when formed.

The distinction between vapor and liquid at great depths may be most conveniently prescribed and defined by the miscibility of the fluid with liquid silicate magma. The liquid may be presumed to be completely miscible with the magma, but the vapor to mix only as an occluded gas; that is to say, in such amounts as its pressure may limit or determine.

The pressures under which the different forms of emanation may exist can be properly determined by experiment only.

Up to the critical point there is a density-criterion to separate the liquid and gaseous states. The specific gravity of water at the critical temperature (365°C.) and pressure (200 atmospheres) is 0.429. This density might possibly be the criterion separating the liquid and gaseous states over a considerable range of temperature-pressure conditions. If this is the case at the temperature of the magma (from 900° to 1,200°C.), a

depth of several miles could be obtained at this temperature before the gaseous condition of water would disappear. We should probably be not far off in assuming that exhalations are so formed at five miles in depth. This is a much greater depth than has hitherto been considered as possible with exhalations; hence we have a new phase of ore-genesis to consider.

General Effect of Temperature and Pressure on Emanations.

Many effects of temperature and pressure on gases are amenable to simple laws. In the case of liquids, however, they are much more complex. Increase of temperature usually increases the solubility of substances; there are a few exceptions. Increase of pressure on solutions is not important. Increase of temperature increases the vapor-density or vapor-pressure of any substance. In dealing with the constituents of an emanation we may be aided by the fact that those which cannot be exhalations must of necessity be residues, and *vice versa.*

Effect of Temperature and Pressure on Exhalations.

The effect of temperature and pressure on gaseous substances may be fairly well estimated.

Every liquid, at every temperature, must be in equilibrium with its own vapor. The vapor-pressure is practically the same for all external pressures. As all gases are perfectly miscible, every gas in contact with a liquid must absorb some of it.

The weight of vapor absorbed per unit-volume is independent of the pressure of the gas, or approximately so. Suppose a vapor has a pressure of one atmosphere and a gaseous solution at 1,000 atmospheres pressure absorbs some of the vapor from its liquid form. The gas will then have one-tenth of 1 per cent. by volume of the vapor. If the gas is that of water, and the liquid that of some metal or mineral, the density of the mineral vapor will be much greater than that of the water, and the percentage by weight will be much more than one-tenth. If the water is a vapor itself, instead of a perfect gas, the quantity will be somewhat different.

It is not the intention of this paper to arrive at exact figures, however, but only to show the right perspective of the great forces involved.

The following is a list of vapor-temperatures at atmospheric

pressure for a few substances for which they have been determined:

Table of Boiling-Points.

	Degrees C.
Mercury,	350
Selenium,	700
Zinc,	960
Lead,	1,040

Since most of these temperatures are a good deal below that of average liquid magma, and vapor-pressures rise in exponential ratio, it is reasonable to suppose that at magma-temperature the vapor-pressures would be many atmospheres.

A pressure of 1,000 atmospheres corresponds to an emanation of equi-pressure-country at about 13,000 ft. of depth, which is perhaps an average depth for exhalation. In general, therefore, we see that the substances tabulated, and many others which we know to be at least as volatile, may be contained in exhalations in sufficient quantity to account for ore-deposits.

It is, of course, not to be presumed that the exhalations remained gaseous, but more often that before they deposited their mineral they became liquid.

Residues.

Reasoning along the same lines, it appears that certain elemental solutes which we know to be contained in emanations must be confined to the residues.

The volatile properties of the real compound substances which enter into emanations have not been determined; as a matter of fact, the exact combinations are not properly known. We know, however, that in general, compounds are less volatile than their constituent metallic elements. The following common ore-minerals are worthy of special discussion:

Silica.—It is extremely unlikely that silica can be a gas under igneous conditions; hence, we may conclude that silica does not occur in exhalations freshly formed. It is quite likely, however, that exhalations may become condensed to the liquid form after they leave the hot magma, and that they may then dissolve colloid silica from the solidified glassy portions of surrounding rocks, or, that some more base constituent of the emanation may replace and take away the silica of other minerals in the rocks it penetrates.

The same argument does not apply to residues, for these may be of liquid form when segregated from the parent magma. As far as my reading and observation go, these conclusions have been borne out. Where pegmatite and more acid deposits are associated with volcanic rocks, there is often evidence that they are the products of expiring vulcanism.

The emanation from basic rocks does not seem to contain much silica. Apparently, therefore, it is only the excess of silica which goes off as emanation. Any silica which can combine with the oxides of the metallic elements to form the less soluble silicates remains in the rocks.

Water is probably given off at greater pressures when there is little or no excess of free silica. This follows from the known fact that colloidal silica shows some affinity for water, an effect which is increased by pressure, there being considerable diminution of volume when colloid silica is dissolved in water.[3]

Silica-Minerals.—The typical silicates, such as those of soda, potash, lime, magnesia, alumina, etc., are presumably held in combination with the silica and do not go off with the aqueous vapors; hence, like silica, when occurring in emanations, they are mainly residues.

Lead, Zinc, Etc.—Lead, zinc, and possibly some copper and other easily volatilized metals, are usually found in the primary condition as sulphides. They may undoubtedly leave the magma as exhalations.

Vapors.

Between the liquid and the gaseous phases of matter there is an intermediate or vaporous phase in which intermediate properties may exist. This vaporous phase is scarcely noticeable at ordinary pressures, but becomes more important when the pressure is such as to give the vapor a density approaching that of the liquid phase.

Many substances may thus be associated with vaporous exhalations which are not volatile in themselves.

Gold and Silver.—Gold occurs in emanations in such small quantities that the general rules applicable to the predominating minerals cannot be applied.

[3] Barus, in *American Journal of Science*, Fourth Series, vol. x., No. 5, p. 173 (Feb., 1900).

Gold and silver may be slightly soluble in vapors of tellurium, etc.; silver in lead, zinc, antimony, etc.

Iron, Copper, Nickel, Etc.—Iron occurs primarily either as one of two sulphides or one of two oxides.

Deposits of pyrite and pyrrhotite are sometimes very massive and free from silica. They contain sulphides of copper, and possibly of nickel, which are evidently derived from the same emanation. They are no doubt often derived from vaporous exhalations.

Tin.—Tin occurs primarily as an oxide, which is only fusible with great difficulty. In all likelihood, it comes from residues.

Minerals Indicating Probable Class of Emanation.

Residues.	Residues and Exhalations.	Exhalations.
Silicas.	Iron Sulphides.	Galena.
Silicates.	Copper Sulphides.	Sphallerite.
Cassiterite.	Nickel Sulphides.	Stibnite.
	Gold- and Silver-minerals.	Realgar.
		Cinnabar.
		Tellurides?

Former Theory and Nomenclature.

The division of emanations into exhalations and residues is not new; but it has not been previously recognized that there is a considerable range of depth at which these two forms may both emanate from the same magma at somewhat different periods of its history.

Residues have been heretofore called pneumatolytic,[4] under the misapprehension that they are gaseous. On the contrary, we have shown that residues have more of the properties of liquids than of gases, so that the name pneumatolytic is out of place.

Exhalations have previously been considered only as belonging to very small depths, and have been called fumarolic. It has apparently been presumed that there was no emanation between the deep-seated "pneumatolytic" and the very shallow "fumarolic" emanations.

The old theory that all good veins ought to be fissures is also losing ground. Many of the most famous mines of the world will probably be found to be intrusive rents. These include nearly all the large stock-works, many flat deposits,

[4] See *Ore-Deposits*, a Discussion; edited by T. A. Rickard.

such as those of Leadville, and most vertical deposits which show no signs of lateral displacement.

It may be necessary to note here that the present paper does not concern itself with the causes of deposition of mineral from the emanations; it eliminates as far as possible all chemical phenomena; and its terms in this respect must be taken as general. Thus, for example, in speaking of the solubility of sulphides, it is not to be understood that the sulphides necessarily go into solution as such.

Indirect Effects of Emanation.

The water contained in magmas may have considerable effect on the crystallization of rocks. Thus, the coarse crystallization of deep-seated granite may not be altogether due to slow cooling. It may, to a very large extent, result from the reduction in viscosity, due to included water. Rocks of similar composition, and cooled just as slowly, but near the surface, do not contain this water, and consequently form fine-grained or even glassy varieties.

Other modes of demonstrating the presence or absence of water during crystallization are at least to be expected: for example, the determination of the exact minerals or proportions of minerals formed by the crystallization of a magma of given composition, *e. g.*, orthoclase and microcline, the latter being formed from the more aqueous solution. It may be presumed that microcline is orthoclase on a greatly magnified scale, this larger crystallization being due to the reduced vicosity of the fluid. Dana[5] says that the essential identity of orthoclase and microcline has been urged by Mallard and Michel-Lévy on the ground that the properties of orthoclase belong to an aggregate of sub-microscopic twinning lamellæ of microcline, according to the albite and pericline laws.

Investigation may show that the amphiboles and pyroxenes are related in some similar manner. The manner of distribution of iron as between higher and lower oxides and sulphides is also open to study.

Experimental Possibilities.

The pressures involved in emanation are not too high to be amenable to experiment. Fire-arms are frequently called upon

[5] Dana, *System of Mineralogy*, 6th ed., p. 323.

to withstand an internal gaseous pressure of 50 tons per square inch, which corresponds approximately to 16 miles of depth under water-head. High-speed steel is now manufactured which has great strength up to a red heat, or 700° C.

The water and other necessary ingredients for a series of experiments could be placed in a tube bored out of this steel. This could be lined with platinum and sealed by calking the

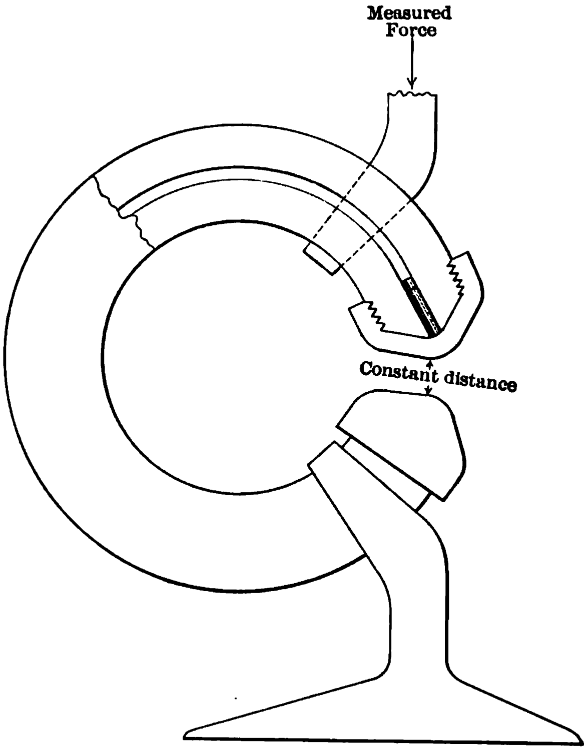


FIG. 2.—SUGGESTED EXPERIMENTAL APPARATUS FOR THE DETERMINATION OF THE PROPERTIES OF EMANATIONS AT MEASURED TEMPERATURES AND PRESSURES.

open end with a platinum plug held in place by a steel screw-cap. If the tube were sealed while the water was kept boiling no air would remain in the tube, and the exact amount of water could be determined by weighing after the tube was sealed. The pressure could be measured by having the tube bent into a circle so that the two ends nearly meet. The distance between the two ends is then an index of the pressure within. The change

of elasticity of the metal with temperature might have to be reckoned with; but it may be practically eliminated by having the distance between the two ends always brought to a constant amount by the imposition of an external stress. This could be accomplished with weights as shown in Fig. 2, the weights required bearing a fixed proportion to the internal pressure. The value of this factor might be determined by connecting the apparatus to as large a known hydrostatic pressure as possible.

If the temperature of the charged sealed tube were gradually raised, and the pressure observed at frequent temperature-intervals, a series of pressure-temperature equivalents of saturated steam would be obtained up to some point below the critical temperature, where the contents of the tube would be all liquid or all gaseous. Above this temperature the density would also be known, as it would remain approximately constant for any series of pressure-temperature observations. Different weights of water could be taken in several different series of pressure-temperature observations.

Every conceivable condition of fluid, as regards its pressure, temperature, and density, might thus be exactly co-ordinated between the two limiting conditions, namely, that of a density or pressure too small to be measured, and that of a pressure or temperature too high for the apparatus to withstand.

Besides the physical properties of water under high temperatures and pressures, there are, of course, to be studied the physical relations of an almost infinite number of solutions and mixtures, which are open to experiment with the same apparatus. There are also numerous chemical reactions to be elucidated. Should not some such experimental investigation be undertaken? The economic importance of the subject seems to me to fully justify it.

Every advance which leads to the more exact classification of mineral deposits limits the need of speculation in mining, gives more basis for local investigation, and in the aggregate lends itself to the saving of wealth. This is the *raison d'être* of the mining engineer.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Direct Determination of Small Amounts of Platinum in Ores and Bullion.*

BY FREDERIC P. DEWEY, WASHINGTON, D. C.

(New York Meeting, February, 1912.)

BY the old method of determining platinum in ores and bullion, the silver-alloy first obtained in the regular course of assay is parted in strong sulphuric acid and the residual metal weighed. This is re-alloyed with silver by a second cupellation and parted in nitric acid, the residual metal being again weighed. Any difference shown between the two weighings is assumed to be, and is called, platinum. Sometimes it is so, and if any considerable amount of platinum be present, there will be a decided difference between the two weighings; but a slight difference is no real evidence whatever of the presence of platinum. On the other hand, the second weight may equal or possibly exceed the first, even when traces of platinum are present. Again, other members of the platinum group may go into solution in nitric acid more or less. If present, these would be called platinum and escape detection. The method does not provide any direct tests whatever as to the presence or absence of platinum. It is often indecisive, and sometimes gives erroneous results. It is, therefore, quite unsatisfactory.

Being called upon many times to determine platinum in a wide variety of materials, particularly when present in very small amounts, I have realized the disadvantages and defects of this old method.

In an article on the solubility of gold in nitric acid,[1] I have briefly outlined a method of gathering a little gold out of a solution containing much silver, which furnishes the basis of

* Published by permission of the Director of the Mint. Published also by permission of the Council in *The Journal of Industrial and Engineering Chemistry*.

[1] *Journal of the American Chemical Society*, vol. xxxii., No. 3, p. 318 (Mar., 1910).

an excellent method for the direct and absolute determination of small amounts of platinum, which has the added advantage that the metal weighed may be subjected to suitable tests, to determine that it really is platinum, and to reveal the presence of other members of the platinum group.

In the regular course of assaying for the precious metals, gold is parted from silver by dissolving the silver in nitric acid. If platinum be present in small amounts only, it will readily go into solution in the nitric acid. If now a limited amount of hydrogen sulphide be added to the solution from parting, any platinum present will be precipitated as sulphide, along with some silver sulphide. On filtering off the precipitate (which generally is sufficiently washed by the operations necessary to transfer it from the precipitating-dish to the filter), the moist filter is transferred to a small porcelain crucible, dried at a low heat, and burned off by gentle ignition. This transforms the sulphide precipitate into a metallic sponge, which is wrapped in a small piece of thin lead foil and cupelled. The resulting bead is then parted in strong sulphuric acid, when the platinum will be left as a dark residue, generally collected in spongy form, even when minute in quantity. This sponge, after reboiling in fresh acid, if necessary, is suitably washed by decantation, annealed, and weighed.

Generally, the final metal speaks for itself as being platinum, but, if there should be any doubt, it may be dissolved in a drop or two of aqua regia and gently evaporated. The solution obtained may be tested with potassium iodide, or a few small crystals of ammonium chloride may be added, when the characteristic precipitate will show itself. As a further test, this may be filtered off and gently ignited to produce spongy platinum. If the amount of the final metal be considerable, the platinum may be determined by the double-chloride method. Any decided difference shown would indicate the presence of other members of the platinum group, for which direct test could then be made.

For precipitating the platinum and the necessary silver from the parting-solution, a very dilute solution of hydrogen sulphide should be used. One part of a strong solution should be diluted to from 10 to 20 parts with water. If the solution of silver nitrate be strongly acid, it should be largely diluted, or

it may first be evaporated and then diluted. The very dilute hydrogen sulphide solution should be added very slowly to the silver nitrate solution with constant stirring. The solution is, of course, at once darkened, but there should be no immediate separation of a visible precipitate. The solution should be stirred occasionally, and in about 2 hr. flocks of precipitate should appear. It may be filtered in from 3 to 4 hr., but it is a good plan to let it stand over night if possible.

The amount of hydrogen sulphide required depends, of course, upon the amount of platinum present. If this should be roughly known or suspected, the amount used should generally be enough to precipitate the platinum and from three to five times as much silver. On an entirely unknown ore, I should at first use 1 cc. of strong hydrogen sulphide solution diluted to 15 cc., and reserve the filtrate from the sulphides for retreatment, if necessary. On an unknown bullion I should use 2 cc. of strong solution diluted to 30 cc., partly because bullions are liable to carry much more platinum than any ordinary ore, and partly because the volume of the silver nitrate solution from parting the gold must necessarily be larger. If, however, it is known that minute amounts of platinum are present, it is still necessary to use sufficient hydrogen sulphide to give a silver bead large enough to handle comfortably. For this reason I seldom use less than the equivalent of 1 cc. of strong hydrogen sulphide solution.

It may happen that the final metal shows the yellow color of gold, due to the fact that exceedingly fine float-gold passed over in decanting the solution of silver nitrate from the gold. In such a case the metal must be re-alloyed with silver and the treatment repeated. When the proportion of gold to silver in the metal being parted is so small that the gold separates in a very finely divided state, it will often save trouble to filter the silver nitrate solution, to separate any float-gold, before adding the hydrogen sulphide.

This method has been used with the utmost satisfaction in determining very minute amounts of platinum in various silver-products directly. Much of our silver coinage, for instance, will show a few tenths of a milligram of platinum in 100 g. of coin. Recently I examined samples from two purchases of fine silver. Very large samples were dissolved in nitric acid.

The acid in portions was poured upon the samples and allowed to act at a gentle heat until exhausted. Finally, a small amount of residual silver was removed from the solution and dissolved in a small amount of fresh acid, the solution being then united with the main solution, and the whole evaporated nearly to dryness. It was then diluted to about 250 cc., and 5 cc. of strong hydrogen sulphide solution diluted to 50 cc. was poured in with constant stirring.

This operation concentrated the gold and platinum of the silver into a small amount of sulphide precipitate. This precipitate was filtered off, roasted, and cupelled. The resulting bead was parted in nitric acid, and the gold was determined. The silver nitrate solution was treated with dilute hydrogen sulphide solution, equivalent to about 1 cc. of strong solution, and the platinum parted from the silver by strong sulphuric acid.

These two samples yielded the following results:

	Silver Taken. Grams.	Gold Found. Milligram.	Platinum Found. Milligram.
No. 1, . .	122.32	0.28	0.67
No. 2, . .	125.47	0.12	0.18

In case we have a material containing a considerable amount of platinum, the well-known fact that platinum alloyed with silver is not entirely soluble in nitric acid must be considered. In such a case the gold from the first parting in nitric acid must be alloyed with silver and parted in nitric acid a second, or even a third, time, before proceeding to precipitate the platinum from the parting-solutions with hydrogen sulphide.

It is also very satisfactory to use the general method of gathering gold in a precipitate of silver sulphide in determining minute quantities of gold in high-grade silver, such as that produced by electrolytic refining. It is comparatively easy to gather the gold from very large samples of silver, up to 100 g. or more, into a decigram of silver, and then part by nitric acid as usual.

Probably this method of precipitating a noble metal in solution, or removing it from suspension in a liquid, by adding hydrogen sulphide in the presence of silver in the solution, could be used to advantage in determining gold in metallic copper and similar materials.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Mine-Caves Under the City of Scranton.

Discussion of the paper of Eli T. Conner, presented at the Wilkes-Barre meeting, June, 1911, and printed in *Bulletin* No. 57, September, 1911, pp. 719 to 737.

RUFUS J. FOSTER, Scranton, Pa. (communication to the Secretary*):—In answer to one of the inquiries made of Mr. Conner, and as a matter of historical record, I beg to say that the idea of supporting the strata over worked-out areas in coal-mines by flushing the openings full of culm originated and was put into actual practice by the late R. C. Luther, a former member of the Institute, at that time Chief Mining Engineer, and later General Manager, of the Philadelphia & Reading Coal & Iron Co.

In the early 80's the Philadelphia & Reading Coal & Iron Co. purchased from Messrs. Hecksher & Co. the Kohinoor colliery, situated in the western part of the borough of Shenandoah, Pa. On taking possession of the colliery the Philadelphia & Reading Coal & Iron Co. made a complete resurvey of the mine-workings, giving an absolutely correct map which showed not only the plan of the mine-workings, but also every improvement on the surface over the workings, and the marked features of the surface of the ground. Tidal elevations were shown at every survey-station in the mine and on the surface, so that, as is the case with all the maps of the company, contour-maps of either the surface or the bottom of any coal-seam, or geological cross-sections, could be constructed directly from the information on the mine-maps.

In a comparatively short time after the company took possession of the colliery, the workings which extended under the western portion of the borough of Shenandoah began to cause trouble and damage dwellings and other buildings in that section of the town. The lots in this section had been sold, in many cases, to individuals by the Gilbert & Shaefer Estate, owners of the coal-lands on which the colliery was located. In

* Received June 17, 1911.

selling these lots, while the mineral right was reserved, there was no clause in the deed, such as is inserted in nearly all the deeds in the city of Scranton, which released the operators of the mine from any damage to the surface or buildings thereon caused by mining coal. The Gilbert & Shaefer Estate repurchased all the lots possible, but on many of them substantial homes had been erected, and the natural increase in the value of the real estate, plus a possible little cupidity on the part of the owners, made it impractical to purchase all of them.

As the workings approached the Roman Catholic church and rectory, which was probably the most expensive property in that section of the town, Mr. Luther realized that if there was a material disturbance of the surface, not only would the operating company be liable for heavy damages on account of the intrinsic value of these buildings, but that there was a sentimental or reverential value to the structures that would have to be considered.

In 1886 he originated the idea of filling the workings with culm. With the very complete mine-map available it was an easy matter to construct a contour-map of the floor of the Mammoth seam, which, by the way, in this place ranged from 40 to 60 ft. thick normally, and which, owing to a peculiar geological formation, doubled back on itself, making a seam of from 80 to 120 ft. thick. In addition, several cross-sections were constructed showing the thickness and character of the strata between the surface and the top of the coal-seam. Bore-holes 8 in. in diameter were sunk with ordinary churn-drills at points so located as to secure the maximum flow of flushed culm in the mine. Pumps were installed to pump water from a convenient stream to the bore-holes, and scraper-lines were put in to convey culm from the large culm-piles to the holes. The culm was then flushed into the mine with the water, and it packed very solidly. As the chambers filled up occasional cross-cuts were driven through pillars into adjoining chambers so as to run the flushed culm into them.

At that time I was connected with the engineering department of the Philadelphia & Reading Coal & Iron Co., and was a member of the corps having this work in charge, and on several occasions I was in the mine and on top of the flushed culm where it ranged in thickness from 60 to 100 ft. This

culm was packed very solidly and compactly by the flushing; the water draining off and flowing to the sump near the foot of the shaft, where, with the ordinary mine-drainage, it was pumped to the surface and flowed into a neighboring stream, to be used over and over again.

After the desired area to be protected was filled there were large quantities of pillar-coal of superior quality which could be taken out, and in some instances short gangways were driven through the culm to reach the pillars. The driving of the gangways or headings through the culm was an easy matter, the fore-poling method of timbering being used. It is my impression that after the pillars were taken out the spaces they occupied were also filled with culm; but of this I cannot speak definitely, as shortly after that time I left the service of the company.

NOTE.—Since writing the above, I have learned that in the latter part of 1885 there was an extensive squeeze in the second and third levels of the Laurel Hill mine, of Messrs. A. Pardee & Co., at Hazélton, Pa. The squeeze was creeping slowly to the west and passed the special timbering as fast as it was put in place. Frank Pardee, then Assistant General Superintendent for A. Pardee & Co., suggested to his father, the late Ario Pardee, and his brother Calvin, then General Superintendent, the plan of flushing two breasts, between the slope and the squeeze, with culm, through bore-holes. The plan was carried out and the result was a complete success. This prior use of the system of flushing, on a comparatively small scale, shows that the credit for first using it belongs to Mr. Pardee. In justice to Mr. Luther, however, it must be recorded that he was unaware of Mr. Pardee's use of culm for the purpose of supporting the overlying strata when he made the plans for the later work at Kohinoor colliery.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Mine-Survey Notes.

Discussion of the paper of George W. Riter, presented at the Canal Zone meeting, November, 1910, and published in *Trans.*, xli., 790 to 796 (1911).

E. R. RICE, Wickenburg, Ariz. (communication to the Secretary*):—While this paper is primarily intended as a discussion of Mr. Riter's, I think it will be best to indicate my criticism by describing my own field-methods. It has been my experience that, for ordinary work, the regular transit-book is to be preferred to the card-system for recording notes. This is specially true when computations in the field are required, for it is then necessary to have at hand the total latitudes, departures, and elevations. Moreover, the transit-book is easier to carry and manipulate in wet or cramped places, and is not as liable to damage as the loose leaf or card.

I use a regular transit-book in the field, and then copy my notes, sketches, etc., in an office-book, entering also the latitudes, departures, and other reductions. These values are then copied into the field-book, securing a duplicate record, in case either book should be lost or mislaid.

In the field-book, the notes are entered on the left-hand, and the sketches and remarks on the right-hand page. The next two pages are left blank for the latitudes, departures, bearings, reduced distances, etc. Of course, the notes for the different parts of the mine are entered in the field-book in the order in which they are surveyed; but in the office-book they are entered systematically.

It has been my experience that the system of keeping notes used by a surveyor, is particularly adapted to the needs and temperament of the individual. Otherwise, he would not be using it. Yet we can all generally learn something from each other; and I describe the system of notes which I employ, in the hope that some one may find something useful in it.

Everything we employ in engineering, whether method or machine, involves two necessary requisites: it must be accurate; and it must be practically "fool-proof." We can all

* Received May 24, 1911.

heartily agree with Mr. Riter when he says, "So seldom does a surveyor have a chance to check underground surveys by making a closure, that he is compelled to rely on the precision of each step of his work for the accuracy of the final result."

In surveying, there are three sources of error to be guarded against, namely: (1) errors in reading the vernier and tape; (2) errors in recording the readings obtained; and (3) instrumental errors. To guard against the first and second, it is necessary to take duplicate readings and measurements on both fore- and back-sights, and to throw all of the reading of the tape on the transit-man, who, by reason of his superior intelligence and training, is better qualified for this work. The third source of error is eliminated by the proper manipulation of the instrument.

The notes should be in such a form that all the duplicate and doubled readings can be recorded without confusion. They should also permit the entry of side-notes necessary for the making of a correct map. They should be simple and easily understood, and should necessitate the recording of as few items as possible. Tables I. and II. give the notes for two courses, as taken from my field-book. The notes are identical, the difference in them being in the position at which the height of the instrument and the height of the point are recorded. Of these two forms, I use the second exclusively, since it permits all the notes to be put on the left-hand page of the note-book, leaving the right-hand page free for remarks and sketches. The second set calls for an entry in every space except one. The notes here given are for two set-ups of the transit: one at station "D," and one at station "E." Stations "C," "D," and "E," are stations in an incline shaft and station "500" is the first station in the 500-ft. level. The instrument is first set up at station "D," the station occupied by the transit being recorded in the Station column. The back-sight is taken on the point "C," and the back-sight station is entered in the Point column, on the same horizontal line as that occupied by the instrument-station. The fore-sight is taken on the point "E," and the fore-sight station is entered in the Point column, on the line below the back-sight station.

The height of the instrument—*i. e.*, the vertical distance from the horizontal axis of the instrument to the point under

or over which the instrument is set—is entered in the Height of Instrument column on the same line as the instrument-station. The "height of point" is the vertical distance, above or below the line of sight, of the point sighted. This is entered in the Height of Point column, on the same horizontal lines as the station to which it refers. In reading horizontal angles, I always set the vernier at zero on the back-sight, and turn the angle to the fore-sight, reading the plate in azimuth, up to 360°. The reading of the vernier on the back-sight is recorded in the Plate column, on the same line as the back-sight station, and the reading of the vernier on the fore-sight is recorded also in the Plate column, on the same line as the fore-sight station. The difference between the two readings is the difference in azimuth between the fore- and back-sights.

The plate is always read in azimuth, because the vernier is then always read in one direction, and there is no necessity of recording whether the angle was read to the right or the left, as is the case when deflection-angles are employed.

After the plate has been read on the fore-sight station, the lower motion is unclamped, the telescope is plunged, and the back-sight is bisected with the cross-wires, by means of the lower slow-motion screw. The upper motion is then unclamped; the telescope is turned on to the fore-sight; the plate is again read; and the reading is recorded just below the first reading, and on the same line. If the instrument is in perfect adjustment, and both readings have been made and recorded correctly, the last reading will be just twice the first.

This doubling of the horizontal angle, with the telescope inverted, serves three purposes: (1) By taking one-half of the last reading as the true value of the angle, the horizontal angle can be more closely determined than if the one reading were made; (2) this method shows whether the plate has been read, and the reading recorded, correctly; and (3) by taking one-half of the last plate-reading as the true angle, all errors due to the lack of adjustment of the line of collimation and the horizontal axis are eliminated. The latter consideration is very important when the sights are inclined.

The vertical angles, or the readings of the vertical circle, are recorded in the Vertical Circle column. The vertical angle of the line of sight to the back-sight is recorded on the same

line as the back-sight station, and that to the fore-sight on the same line as the fore-sight station.

By reading the vertical angles, and measuring the distances, of both the fore- and back-sights, and taking the mean of the horizontal and vertical distances obtained as the true distances, index-errors of the vertical circle, and errors due to the lack of adjustment of the bubble attached to the telescope, are eliminated. I notice that Mr. Riter reads the vernier of his vertical circle both direct and reversed, to guard against mistakes in reading the vertical circle.

After recording the vertical angle, I set my vertical circle so that the vernier reads 17 min. more or less than the recorded reading, and then see if one of the stadia-hairs cuts the point sighted at. The distances measured are entered in the Distance column, on the same line as the points to which the distances are measured. If a distance is measured horizontally, then the reading of the vertical circle will be zero.

In measuring distances, I always measure from the axis of the instrument to the point sighted at. The vertical circle reading then gives the inclination of the tape from the horizontal. I always make the chain-man hold the zero of the tape at the point sighted, while I read the tape at the axis of the instrument. Under this procedure, if any mistakes are made, I make them; and I am not always bothering as to whether the chain-man read the tape correctly or not.

By taking measurements on both the fore- and back-sights, I have an absolute check on myself. This is a refinement in ordinary work; but where the survey is important, it is absolutely necessary. It does not take long to make the extra measurement and reading, and by so doing, and taking the mean of the results obtained from the fore- and back-sight measurements, systematic instrumental errors are kept from accumulating.

The side-notes go on the line below that occupied by the fore-sight to which the side-notes refer. If more than one point is sighted from the set-up, the other fore-sights go on the line below the side-notes of the preceding fore-sight.

In the notes here given, the transit is set up under "D," the height of instrument being 4.02 ft., and the back-sight is taken on the head of a plumb-bob suspended from "C." The height

of the back-sight station above the line of sight—*i. e.*, above the head of the plumb-bob—is + 5.19 ft., and the slope-distance from the axis of the instrument to the head of the plumb-bob is 80.55 ft., and the vertical angle of the line of sight is + 30° 46′ 30″.

The vernier of the horizontal circle is set at zero on the back-sight, as indicated in the Plate-column. The horizontal angle is turned to "E" and the plate read in azimuth, the reading being 179° 58′ 30″. The fore-sight is taken on the head of a plumb-bob suspended from "E," the height which is + 5.36 ft. The vertical angle of the line of sight is — 35° 22′ 0″, and the distance from the axis of the instrument to the head of the plumb-bob is 109.94 feet.

The lower motion is then unclamped, the telescope is plunged, and the plumb-line at the back-sight is again sighted. The upper motion is then unclamped and the plumb line at station "E" is again sighted. The plate is read in azimuth, and found to read 359° 57′ 0″. As this is twice the first reading, we are sure that our first angle is correct. The side-notes are then recorded. The distances from the instrument towards the fore-sight are recorded as whole numbers, and the distances from the line of sight to the walls are recorded as fractions, the numerator of the fraction being the distance from the line of sight to the left wall, and the denominator the distance to the right wall. Thus, at the instrument, the distance from the instrument to the left wall is 3.6 ft. and to the right 3.3 ft. At 20 ft. from the instrument, it is 3.2 ft. to the left wall and 4.1 ft. to the right; and so on.

If it is necessary for mapping to get the outlines of the floor and roof, the same scheme can be used—recording the distance from the line of sight to the roof as the numerator, and the distance to the floor as denominator.

A reduction of the above notes will show that from the data obtained at station "D," the horizontal distance between "D" and "E" is 89.65 ft., while the vertical distance is 62.29 ft. From the data obtained at station "E," the horizontal distance is 89.64 ft. and the vertical 62.3 ft. As these values agree with each other, and as one-half the doubled horizontal angle is equal to the single angle at station "D," we are sure that our work is correct.

It is a great deal easier to compute the bearing of a line from its azimuth than in any other way. When the azimuth is known, its bearing can be determined mentally, by the following rule: To find the azimuth of a line, add to the azimuth of the preceding line the horizontal angle and 180°. Thus: The bearing of the line C–D is N. 45° 2′ 30″ E.; hence its azimuth is 225° 2′ 30″, namely:

	225° –02′ –30″
	179° –58′ –30″
	180° –00′ –00″
	585° –01′ –00″
Less	360° –00′ –00″
	225° –01′ –00″

225° –01′ –00″ is the azimuth of the line D–E; hence its bearing is N. 45° –1′ –0″ E.

To get the bearing of the line E–500, we would proceed as follows:

	225° 01′ 0″
	76° 50′ 0″
	180° 00′ 0″
	481° 51′ 0″
Less	360° 0′ 0″
	121° 51′ 0″

121° 51′ 0″ is the azimuth of the line E–500; hence its bearing is N. 58° 09′ 00″ W.

For accurate work, it is essential that the instrument be perfectly level; and since the ordinary plate-levels are too sluggish, and generally not quite in adjustment, I level the transit for important work by means of the bubble attached to the telescope, after approximately leveling it by means of the plate-levels.

In computing the vertical and horizontal distances, as well as the latitudes and departures, I use a Gurdens traverse-table, and check the results by means of a slide-rule. The system of notes here given can be used with equal facility for either underground- or surface-work. In ordinary surface-work, the height of instrument, height of point, and the back-sight vertical circle, and D readings, as well as the side-notes, can be omitted.

TABLE I.—*Record of Field-Notes.*

Station.	Point.	Height of Instrument.	Height of Point.	Plate.	Vertical Circle.	D.
D	C	— 4.02	+ 5.19	0 0	+ 30° - 46′ - 30″	80.55
				179 - 58 - 30		
	E		+ 5.36	359 - 57 - 00	— 35 - 22 - 00	109.94
$0\,\frac{3.6}{3.3}$	$20\,\frac{3.2}{4.1}$	$40\,\frac{4.0}{3.0}$	$60\,\frac{3.6}{3.4}$	$80\,\frac{3.5}{3.5}$	$100\,\frac{4.0}{3.0}$	
E	D	— 4.08	+ 6.18	0 0	+ 33 - 53 - 30	107.98
				76 - 50 - 00		
	500		+ 3.84	153 - 40 - 00	0 0	18.20
$6\,\frac{\text{S. P.}}{8.0}$	$7\,\frac{1.5}{6.5}$	$10\,\frac{0.1}{5.5}$	$18\,\frac{2.0}{2.4}$			

TABLE II.—*Alternative and Preferable Record of the Field-Notes Given in Table I.*

Station.	Point.	Plate.	Vertical Circle.	D.
— 4.02	+ 5.19			
D	C	0 0	+ 30 - 46 - 30	80.55
	+ 5.36	179 - 58 - 30		
	E	359 - 57 - 00	— 35 - 22 - 00	109.94
$0\,\frac{3.6}{3.3}$	$20\,\frac{3.2}{4.1}$	$40\,\frac{4.0}{3.0}$ $60\,\frac{3.6}{3.4}$	$80\,\frac{3.5}{3.5}$	$100\,\frac{4.0}{3.0}$
— 4.08	+ 6.18			
E	D	0 0	+ 33 - 53 - 30	107.98
	+ 3.84	76 - 50 - 00		
	500	153 - 40 - 00	0 0	18.20
$6\,\frac{\text{S. P.}}{8.0}$	$7\,\frac{1.5}{6.5}$	$10\,\frac{0.1}{5.5}$	$18\,\frac{2.0}{2.4}$	

No. 65 MAY 1912

Bulletin of the American Institute of Mining Engineers.

CONTENTS:

SECTION I.—INSTITUTE ANNOUNCEMENTS

SECTION II.—PAPERS AND DISCUSSIONS.

BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

No. 65 MAY 1912

PUBLISHED MONTHLY
BY THE AMERICAN INSTITUTE OF MINING ENGINEERS
at 124 to 128 N. Seventh St., Philadelphia, Pa.
Guy R. Overend, Publication Manager.

Editorial Office, 29 West 39th St., New York, N. Y.

JOSEPH STRUTHERS, Ph.D., Editor.

Cable address, "Aime," Western Union Telegraph Code.

Subscription (including postage), $10 per annum; to members of the Institute, public libraries, educational institutions and technical societies, $5 per annum.

Single copies (including postage), $1 each; to members of the Institute, public libraries, etc., 50 cents each.

Entered as second class matter, October 16, 1911, at the post office at Philadelphia, Pa., under the Act of March 3, 1879.

TABLE OF CONTENTS.

SECTION I. INSTITUTE ANNOUNCEMENTS.

SECTION II. TECHNICAL PAPERS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

The papers contained in Section II. have been so printed and arranged (blank pages being left when necessary) that they can be separately removed for classified filing, or other independent use. A small stock of separate pamphlets is reserved for those who desire extra copies of any single paper.

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

All communications concerning the contents of this Bulletin should be addressed to JOSEPH STRUTHERS, Ph.D., Secretary and Editor, 29 W. 39th St., New York, N. Y.

OFFICERS.

For the year ending February, 1913.

COUNCIL.*

PRESIDENT OF THE COUNCIL.

JAMES F. KEMP .... NEW YORK, N. Y.

(Term expires February, 1913.)

VICE-PRESIDENTS OF THE COUNCIL.

S. B. CHRISTY .... BERKELEY, CAL.
R. V. NORRIS .... WILKES-BARRE, PA.
GARDNER F. WILLIAMS .... WASHINGTON, D. C.

(Term expires February, 1913.)

KARL EILERS .... NEW YORK, N. Y.
WALDEMAR LINDGREN .... WASHINGTON, D. C.
BENJAMIN B. THAYER .... NEW YORK, N. Y.

(Term expires February, 1914.)

COUNCILORS.

ROBERT E. JENNINGS .... NEW YORK, N. Y.
WILLIAM KELLY .... VULCAN, MICH.
HENNEN JENNINGS .... NEW YORK, N. Y.

(Term expires February, 1913.)

A. E. CARLTON .... CRIPPLE CREEK, COLO.
W. J. OLCOTT .... DULUTH, MINN.
E. L. YOUNG .... NEW YORK, N. Y.

(Term expires February, 1914.)

JOHN H. JANEWAY, JR. .... NEW YORK, N. Y.
SIDNEY J. JENNINGS .... NEW YORK, N. Y.
JOSEPH W. RICHARDS .... SOUTH BETHLEHEM, PA.

(Term expires February, 1915.)

SECRETARY OF THE COUNCIL AND EDITOR.

JOSEPH STRUTHERS, 29 W. 39th St. .... NEW YORK, N. Y.

(Term expires February, 1913.)

SECRETARY EMERITUS OF THE COUNCIL.

R. W. RAYMOND .... NEW YORK, N. Y.

CORPORATION.

JAMES F. KEMP, President; EDMUND B. KIRBY, Vice-President;
FRANK LYMAN, Treasurer; GEORGE C. STONE, Secretary;
JOSEPH STRUTHERS, Assistant Secretary and Assistant Treasurer.

DIRECTORS.

JAMES GAYLEY, CHARLES KIRCHHOFF, FRANK LYMAN.

(Term expires February, 1913.)

JAMES DOUGLAS, JAMES F. KEMP, ALBERT R. LEDOUX.

(Term expires February, 1914.)

EDMUND B. KIRBY, CHARLES F. RAND, GEORGE C. STONE.

(Term expires February, 1915.)

Consulting Attorneys, Blair & Rudd, New York, N. Y.

* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation.

COMMITTEES.

For the year ending February, 1913.

COUNCIL.

Membership:—Joseph Struthers, Karl Eilers, Sidney J. Jennings, Benjamin B. Thayer, John H. Janeway, Jr.

Publications:—Joseph Struthers, *Chairman;* David W. Brunton, Samuel B. Christy, Albert L. Colby, Nathaniel H. Emmons, Charles H. Fulton, James Gayley, H. O. Hofman, Henry M. Howe, Walter R. Ingalls, James F. Kemp, R. V. Norris, Edward D. Peters, Rossiter W. Raymond, Joseph W. Richards, Robert H. Richards, Albert Sauveur, Henry L. Smyth, Arthur L. Walker.

Iron and Steel Division:—Charles Kirchhoff, *Chairman;* Charles F. Rand, *Vice-Chairman;* Bradley Stoughton, *Secretary;* John Birkinbine, James Gayley, Henry D. Hibbard, Henry M. Howe, Robert W. Hunt, Julian Kennedy, Charles K. Leith, Richard Moldenke, Joseph W. Richards, F. W. C. Schniewind, Felix A. Vogel, Leonard Waldo, William R. Webster.

CORPORATION.

Finance:—Charles F. Rand, James Gayley, George C. Stone.

Library:—James F. Kemp, Charles Kirchhoff, George C. Stone.

Land Fund:—James Douglas, *Chairman*; Theodore Dwight, *Treasurer;* T. F. Cole, Anton Eilers, James Gayley, John Hays Hammond, Charles Kirchhoff, Albert R. Ledoux, Frank Lyman.

INSTITUTE REPRESENTATIVES.

United Engineering Society Trustees:—Joseph Struthers (1913), Theodore Dwight (1914), James F. Kemp (1915).

Joint Conference Committee of the Four National Engineering Societies:—James F. Kemp, Joseph Struthers.

John Fritz Medal Board of Award:—E. Gybbon Spilsbury (1913), R. V. Norris (1914), Charles Kirchhoff (1915), J. F. Kemp (1916).

American Association for the Advancement of Science:—H. O. Hofman, John D. Irving.

Eighth International Congress of Applied Chemistry, New York, September, 1912:—William L. Saunders, George C. Stone.

Sixth Congress of the International Association for Testing Materials, September, 1912:—Robert Forsyth.

Committee No. 24, International Association for Testing Materials:—Henry D. Hibbard.

International Engineering Congress, San Francisco, 1915:—Samuel B. Christy, William C. Ralston, Edwin T. Blake.

Kelvin Memorial Committee:—James F. Kemp, Samuel B. Christy, James Douglas, Joseph Struthers.

Conference to Discuss Patent Laws:—A. F. Lucas, ————, ————.

INSTITUTE ANNOUNCEMENTS.

Acts of the Council.

The following notes from the minutes of the meeting of the Council, April 26, 1912, are here published for the information of the members:

Appointment of Committee to establish an Iron and Steel Division of the Institute: Charles Kirchhoff, *Chairman;* Charles F. Rand, *Vice-Chairman;* Bradley Stoughton, *Secretary;* John Birkinbine, James Gayley, Henry D. Hibbard, Henry M. Howe, Robert W. Hunt, Julian Kennedy, Charles K. Leith, Richard Moldenke, Joseph W. Richards, F. W. C. Schniewind, Felix A. Vogel, Leonard Waldo, William R. Webster.

Appointment of Mr. John H. Janeway, Jr., to fill the vacancy in the Committee on Membership.

Special Notice.

The *Bulletin* is now entered at the Post Office at Second-Class Postage rate of one cent per pound, and in order to preserve this privilege it is necessary that the dues of members be paid within four months of January 1 of each year. If the dues are not paid within the period mentioned, a member's name must be removed from the regular subscription-list and the *Bulletin* mailed at the transient second-class postage rate of one cent for each four ounces or fraction thereof, prepaid by stamps affixed. It is therefore earnestly requested that dues be paid promptly—otherwise the Institute will be put to additional expense of postage and to added labor in removing and replacing names from the regular list, and in maintaining an additional separate mailing-list.

The New York Section.

On April 16, 1912, Mr. Carleton Ellis presented a paper, illustrated by lantern-views, on Prof. William A. Bone's process of Surface, or Flameless, Combustion. The meeting was well attended, and the paper was discussed by Dr. Arthur H. Elliot, C. A. Meissner, Anton Eilers, Prof. Charles E. Lucke, and others. It is hoped to publish this paper and the discussions in full in a future issue of the *Bulletin.*

The annual meeting of the Section was held on Friday evening, May 3, 1912. Mr. Stoughton presided. The report of the Secretary-

Treasurer announced that nine meetings has been held during the year, as described in the *Bulletin*. The total expenses for hall, lantern and operator, printing, postage, and refreshments during the year were $599.29, and voluntary subscriptions received from 15 interested members of the Institute amounted to $654.20, leaving a balance of $54.91 to be carried over.

The following officers were elected for the ensuing year:

Chairman, ...	Dr. George F. Kunz.
Vice-Chairman, ...	William H. Nichols, Jr.
Secretary-Treasurer, ...	Louis D. Huntoon.
One member of the Executive Committee,	Thomas Robins.

BRADLEY STOUGHTON,
Secretary-Treasurer.

Directly following the election, Chairman Kunz officiated as presiding officer, and introduced Prof. L. C. Graton and Mr. H. Murdock, both of Harvard University, who presented a paper on The Mineral Relations of Copper Sulphide Ores as Revealed by the Microscope, illustrated by lantern-projections in natural colors, magnified about 800 diameters.

This interesting paper was discussed by Prof. James F. Kemp and Prof. William Campbell, of Columbia University, and others. Probably both the paper and the discussions in full will be published later in the *Bulletin*.

A pleasing innovation at the March, April, and May meetings was the holding of an informal reception and smoker in the rooms of the Institute, directly after the close of the technical session.

LOUIS D. HUNTOON,
Secretary-Treasurer.
165 Broadway, New York, N. Y.

Library Research-Work.

The attention of members of the Institute is again directed to the research-work done by the librarian and his assistants, which should attract special attention from those members who have no access to the literature of subjects in which they may be interested.

During the year 1911 there were 143 searches made for members and non-members of the Founder Societies, and copies of the references have been preserved for the use of others. This work has been largely based on requests sent in by mail, from Japan, South Africa, Mexico, Canada, and England, as well as from different parts of the United States. The Librarian is confident that if it were more widely known that the library is equipped to undertake researches, the demand would increase beyond the ability of the present force to handle it. The library receives more than 700 technical periodicals which are available through the indexes for this special purpose.

Back Volumes of the Transactions.

The Board of Directors has authorized the following offers of sets of back volumes of the *Transactions*, at considerably reduced prices, to Members, Libraries, and Scientific Societies:

		Per Set.
I.	Five volumes, bound in half-morocco, from No. 36 (1906) to No. 40 (1910), ...	$20
II.	Ten volumes, bound in half-morocco, from No. 31 (1902) to No. 40 (1910), including Mexican Volume, . . .	35
III.	Twenty volumes, bound in half-morocco, from No. 21 (1893) to No. 40 (1910), ...	50
IV.	Thirty volumes, bound in half-morocco, from No. 11 (1883) to No. 40 (1910), ...	60
V.	Thirty-nine volumes, bound in half-morocco, from No. 1 (1873) to No. 40 (1910), with the exception of No. 10 (1882), but including index for Volumes Nos. 1 to 35, and Nos. 36 to 40, ...	75
VI.	Nine volumes, bound in half-morocco, from No. 1 (1873) to No. 9 (1881), ...	25

Applications should be addressed to Joseph Struthers, Secretary, 29 West 39th Street, New York, N. Y.

Local Sections.

The following regulations for the establishment of Local Sections of the Institute, issued in circular form and distributed to the membership May 26, 1911, are here republished for more convenient reference.

Regulations for the Formation and Conduct of Local Sections.
(Adopted May 19, 1911.)

1. A Local Section of the Institute may be authorized by the Council at the written request of *ten* members residing within an appropriate distance of a central point.
2. Only one Section shall be authorized in one locality or district.
3. The Council shall define the territory of a Section.
4. A Section must consist of twenty-five or more members; when its membership falls below twenty-five in number the Council may annul the Section.
5. Only members of the Institute shall be members of its Local Sections.
6. All members of the Institute, of all grades, residing within the territory of a Section shall *ipso facto* constitute the membership of such Section.
7. The officers of a Section shall be elected after the formation of the Section has been duly authorized, at a meeting of the members of the Institute within the territory of said Section, called by the sponsors of the Section, notice of said meeting and its object being given to said members at least thirty days in advance. Officers shall be elected for a term not longer than one year.

8. The officers of a Local Section shall be a Chairman, Vice-Chairman, Secretary, Treasurer (or Secretary-Treasurer), and such others as the Section may desire.

9. Whenever the Institute is financially able to do so, it shall be the policy of its Board of Directors to contribute from its funds for the legitimate running expenses of each Local Section an amount not exceeding, in each year, 25 per cent. of the dues received from the members of said Section in said year. Requests for such appropriations shall be signed by the Chairman, Secretary and Treasurer of the Section.

10. If the expenses of a Section exceed the appropriation made it by the Institute, the difference must be made up by voluntary contributions, but not by assessment upon the members of said Section. The Institute shall not be responsible for the debts of its Sections.

11. The Institute reserves the right to cancel a Section, or re-adjust its territory.

12. Papers presented at Local Sections, and discussions thereon if reported, are the property of the Institute. They shall be submitted to the Publication Committee and published in the *Bulletin* or *Transactions*, or both, if approved. Such papers shall not be published elsewhere without permission of the Council. The reading of a paper before a Local Section shall not carry with it the right of publication in the *Bulletin* or *Transactions* of the Institute.

13. Neither the author of a paper presented to a Local Section nor the Local Section shall have the right to reprint a paper or publish it in advance of the meeting without obtaining the permission of the Publication Committee of the Institute, which shall determine the details of such permission. Nothing herein shall forbid the abstracting of a paper by the press *after* its presentation before the Local Section.

14. The Institute shall print advance copies of papers offered to Local Sections, in order to facilitate discussion thereon, provided that such papers are approved for such advance publication by the Chairman or Secretary of the Local Section and by the Publication Committee of the Institute.

15. Papers read before a Local Section may also be offered for reading or discussion at general meetings of the Institute, and shall be given equal standing with the other papers on the program of said meeting, when approved by the Publication Committee.

16. Each Local Section shall transmit promptly to the Secretary of the Institute full announcements of its proposed meetings and an abstract of its proceedings, including the names of authors and titles of all papers read before it, for the purpose of preparing a report thereon to be published in the *Bulletin* of the Institute, and for the purpose of enabling the Council of the Institute to comply with articles 17 and 19 of these regulations.

17. The By-Laws and regulations of Local Sections shall be subject to the approval of the Council.

18. The Council reserves the right to amend, annul, or add to these regulations.

19. No action shall be taken by a Section which shall contravene the Constitution of this Institute.

The Emmons Research Fellowship of Economic Geology.

The Committee named below has been formed by friends of Samuel Franklin Emmons, late of the United States Geological Survey, to consider the best method of perpetuating his name. It has been decided that the memorial to him shall take the shape of a Research Fellowship, to be known as the Samuel Franklin Emmons Research Fellowship of Economic Geology, which is to be administered by Prof. James F. Kemp, of Columbia University, New York. Subscriptions are invited by his friends to this fund, which the Committee has fixed at $25,000.

Members of the Institute who desire to contribute to this fund will please communicate with the Treasurer, Benjamin B. Lawrence, 60 Wall Street, New York.

The Committee consists of the following:

GEORGE OTIS SMITH, Director, U. S. Geological Survey, Washington, D. C.
H. L. SMYTH, Harvard University, Cambridge, Mass.
JAMES DOUGLAS, 99 John Street, New York, N. Y.
J. A. HOLMES, Director, Bureau of Mines, Washington, D. C.
JAMES F. KEMP, Columbia University, New York, N. Y.
F. W. BRADLEY, San Francisco, Cal.
J. PARKE CHANNING, 42 Broadway, New York, N. Y.
SEELEY W. MUDD, 1001 Central Building, Los Angeles, Cal.
D. W. BRUNTON, Denver, Colo.
H. FOSTER BAIN, 420 Market Street, San Francisco, Cal.
T. A. RICKARD, London, England.
B. B. LAWRENCE, 60 Wall Street, New York, N. Y.

Regulations for the Committee on Publication.

(*Adopted June* 16, 1911.)

1. The formation of a Publication Committee, consisting of the Secretary-Editor of the Institute, *Chairman*, and of at least twelve specialists, members of the Institute, who are willing to assist in passing on all papers offered for publication.

2. This committee shall perform its functions as follows:

(*a*) On the receipt of a paper by the Secretary, he shall send it to the member of this committee who, in his judgment, is most competent to pass upon it, accompanying the paper with his own opinion of its suitableness for publication, the history of the paper, and any other pertinent information.

(*b*) If the member of the committee and the Chairman agree upon the suitability or unsuitability of the paper, it shall be considered accepted for publication or rejected, as the case may be.

(*c*) If these two do not agree, the paper shall be submitted to a third, and the opinion of two of these three shall decide the matter.

(*d*) If a paper has been refused publication, the author may have the right of appeal, in which case the persons previously passing

on the paper, together with others of the committee (appointed by the President) making five altogether, shall decide the question.

(*e*) If a paper has been accepted for publication, it shall be considered eligible to be placed on the program of a meeting.

3. The placing of a paper upon the program of a meeting does not give it the right to be published in the *Bulletin* or *Transactions* of the Institute; its suitability for publication must in every case be passed upon by the Publication Committee, as provided for in Section 2.

4. In case the Secretary is unable to secure a decision as to the suitability or unsuitability of a paper for publication, as directed in Section 2, before the time of announcing the program of a meeting, he may at his own discretion place the paper upon the program of the meeting, or refuse it a place thereon.

Affiliated Student Societies.

Any society of undergraduates at a technical school, comprising students in any branch of engineering, metallurgy, chemistry, geology, etc., may be recognized by the Council in its discretion as an Affiliated Student Society. A circular giving details of the plan of affiliation may be obtained on application to the office of the Secretary of the Institute.

The following societies have been placed by authority of the Council on the above list:

AFFILIATED STUDENT SOCIETIES.

The Mining Society of the Sheffield Scientific School, Yale University, New Haven, Conn. *President*, Karl C. Stadtmiller; *Secretary*, S. B. Gordy.

The University of Illinois Student Branch of the American Institute of Mining Engineers, Champaign, Ill. *President*, Leonard V. Newton; *Secretary*, L. W. Swett.

The Engineering Society of the University of Nevada, Reno, Nev. *President*, D. E. Bruce; *Secretary*, R. M. Seaton.

The University of Wisconsin Mining Club, Madison, Wis. *President*, Rudolph J. Stengl; *Secretary*, Mack C. Lake.

The Mining and Geological Society of Lehigh University, South Bethlehem, Pa. *President*, William E. Fairhurst; *Secretary*, Carl W. Mitman.

The School of Mines Society of the University of Minnesota, Minneapolis, Minn. *President*, Emory P. Baker.

The Mining Engineering Society of the Massachusetts Institute of Technology. *President*, L. B. Duke; *Secretary*, Lionel H. Lehmaier.

The Student Auxiliary Society of the American Institute of Mining Engineers of the University of Kansas, Lawrence, Kan. *President*, A. H. Mangelsdorf; *Secretary*, C. J. Hainbach.

The Associated Miners of the University of Idaho, Moscow, Idaho. *President*, James W. Gwinn; *Secretary*, J. Wallace Strohecker.

The State College of Washington Mining and Geological Society, Pullman, Wash. *President*, H. E. Doelle; *Secretary*, B. R. Kinney.

The Tejas Technical Society, School of Mines, University of Texas. *President*, G. C. Cartwright; *Secretary*, David S. Alley.

The Ohio State University Student Branch of the American Institute of Mining Engineers, Columbus, Ohio. *President*, Hugh B. Lee; *Secretary*, E. P. Elliott.

The Stanford Geology and Mining Society, Stanford University, Cal. *President*, B. E. Parsons; *Secretary*, E. D. Nolan.

The Senior Mining Society of Columbia University, New York, N. Y. *President*, Roger L. Strobel; *Secretary*, Clark G. Mitchell.

Mining Association of the University of California, Berkeley, Cal. *President*, Frank L. Wilson; *Secretary*, Stanley L. Arnot.

Tufts College Chemical Society, Tufts College, Mass. *President*, P. G. Savage; *Secretary*, W. S. Frost.

University of Washington Mining Society, Seattle, Wash. *President*, Horace H. Crary; *Secretary*, Clinton R. Lewis.

Student Branch of the American Institute of Mining Engineers, Iowa State College, Ames, Iowa. *President*, M. B. Hadley; *Secretary*, R. L. Hurst.

Missouri Mining Association of the Missouri School of Mines, Rolla, Mo. *President*, D. L. Forrester; *Secretary*, J. S. Irwin.

The Pick and Shovel Club of the Case School of Applied Science, Cleveland, Ohio. *President*, L. B. Riddle; *Secretary*, S. C. Stillwagon.

Colorado School of Mines Scientific Society, Golden, Colo. *President*, Alan Kissock; *Secretary*, George Wilfley.

Mining Engineering Society of the University of Arizona, Tucson, Ariz. *President*, James J. Flanigan; *Secretary*, H. O. Coles.

How to Use the "Transactions" of the Institute.

Buy a copy of the Complete Analytical and Alphabetical Index of Volumes I. to XXXV., inclusive; also the new Index of Volumes XXXVI. to XL.

Whether you do or do not own a full set of the *Transactions*, these Indexes will make all of the material contained in the forty volumes available at once without detailed research into each volume separately. Moreover, an easy search will show what particular papers you need to know more about, and perhaps to study. Thus, any person possessing these Indexes can ascertain at once what has been published in the *Transactions* on a given question, and can learn, by writing to the Secretary, what is its nature, whether it is still to be had in pamphlet form, where it can be consulted in a public library, at what cost it can be copied by hand, etc., etc.

In short, to those who own complete sets of the *Transactions*, these Indexes will be a great convenience; but to those who do not, they will be a professional necessity.

The Index Volumes I. to XXXV. is an octavo of 706 pages, containing more than 60,000 entries, duly classified with sub-headings, and including abundant cross-references. The limited edition is becoming exhausted. The new Index, Volumes XXXVI. to XL., supplementing the Index Volumes I. to XXXV., brings the classified references up to the date of Volume XL., June, 1910. Prices: Index Volumes I. to XXXV., bound in cloth, $5; bound in half-morocco, to match the *Transactions*, $6. Index Volumes XXXVI. to XL., bound in cloth, $1.50; bound in half-morocco, $2.50. The delivery charges will be paid by the Institute on receipt of the above price.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
AMERICAN INSTITUTE OF MINING ENGINEERS.
UNITED ENGINEERING SOCIETY.

WILLIAM P. CUTTER, Librarian.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

The Library contains about 42,000 volumes, including sets of technical periodicals and the publications of scientific and technical societies.

The members of the Institute, with few exceptions, are by the very nature of their profession forced to spend a large portion of their time in localities isolated from sources of information. To such members the Library can render valuable service through correspondence, and letters requesting information will receive special attention. The Library is prepared to furnish references and copies of articles on mining and metallurgical subjects; to determine, if possible, the existence of mining-maps, and to furnish general information as to the geology and mineral resources of all countries as far as these resources are known and published.

It is hoped that the members of the Institute will avail themselves freely of this special service. The Library will welcome inquiries on engineering subjects, and furnish information as far as such information is to be obtained.

All communications should be made as definite as possible so that the information received may be what is desired and not include collateral matter which may not be of interest. In this way the time spent in searching for such collateral matter will be saved, and as a result the information will be sent more promptly and in more usable shape.

The members of the Institute can be of service to the Library by forwarding copies of mining-reports, maps privately issued, and similar material, which will be classified, indexed, and made available to other members.

Suggestions for additions to the Library, either by purchase or personal solicitation as gifts, will be welcomed. It is hoped that members while in the city will use the Library freely, and assurance is given that most careful service will be rendered to them.

Library Accessions.

Apr. 1 to Apr. 30, 1912.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

ALASKAN COAL PROBLEMS. (Bulletin No. 36, U. S. Bureau of Mines.) Washington, 1911. (Exchange.)

AMERICAN INSTITUTE OF MINING ENGINEERS. Monthly Bulletin, 1911. New York, n. d.

——— Year Book, 1912. New York, 1912.

BROKEN HILL SOUTH SILVER MINING CO. Reports, Statements of Accounts, etc., for half year ended Dec. 31, 1911. Melbourne, 1911. (Gift of W. E. Wainwright.)

BUILDING STONES AND CLAYS: THEIR ORIGIN, CHARACTERS AND EXAMINATION. By E. C. Eckel. New York, J. Wiley & Sons, 1912. Price, $3 net. (Gift of Publishers.)

[NOTE.—The great importance of the mining and manufacturing industry connected with building-stones and clays has but recently been recognized; and technical literature, reflecting, as it always does, the movements of commercial enterprise, is bearing witness to this new development. To the works of Smock, Ries and others, this treatise is now added. Part I. deals in successive chapters with the origin and structure of rocks; igneous rocks in general; granites and other igneous rocks; trap-rock and other igneous stones; serpentine and soapstone; sedimentary rocks in general; slates; sandstones; limestones; marbles; field-examinations and valuation of stone-properties; and laboratory-testing of stone. Part II. treats of the general classification of clays; residual clays; transported clays; the distribution of clays; and the field-examination of clay-deposits. The volume contains, in 264 pages, including many tables and illustrations, an outline of its subject, probably as clear and complete as could be given in that space. It should be valuable both for study and for reference.—R. W. R.]

CAPE OF GOOD HOPE GEOLOGICAL COMMISSION. Annual Report, 15th, 1910. Cape Town, 1911. (Exchange.)

COAL NEAR THE BLACK HILLS, WYOMING, SOUTH DAKOTA. (Bulletin No. 499, U. S. Geological Survey.) Washington, 1912. (Exchange.)

CYANIDE PRACTICE, TEXT BOOK OF. By H. W. MacFarren. New York, McGraw-Hill Book Co., 1912. Price, $3 net. (Gift of Publishers.)

[NOTE.—This is one of many practical summaries of the theory and practice of the cyanide process which have accompanied the rapid development and application of that process throughout the world. While it does not profess to be a profound scientific treatise, it contains a good deal of "popular-scientific" statement, and its discussion of the chemistry of cyanide solutions seems to be sound, so far as it goes. But it is chiefly designed as an up-to-date manual of practice; and in this respect, being the latest book, it should be one of the best; for the swift succession of improvements in practice requires a corresponding succession of reports. In this branch, as in that of applied electricity, the shop is always ahead of the class-room. But the value of Mr. MacFarren's practical summary is immensely augmented by an excellent classified bibliography, from which the reader of his book may learn, not merely the names of books upon the subject, but also those of treatises and papers on each particular branch of it. This feature gives the book a special, unique value.—R. W. R.]

DEUTSCHE CHEMISCHE GESELLSCHAFT. Mitglieder Verzeichnis, 1912. Berlin, 1912. (Exchange.)

DICTIONARY OF APPLIED CHEMISTRY. Vol. I. By Edward Thorpe. London-New York, 1912. (Purchase.)

DISTRIBUTION OF MINERALS IN THE JAPANESE EMPIRE AND THE COREAN PENINSULA, WITH MAPS. N. p., n. d. (Exchange.)

FIELD MUSEUM OF NATURAL HISTORY. Annual Report of the Director, 1911. Chicago, 1912. (Gift of Field Museum of Natural History.)

GEOLOGY OF THE GREYMOUTH SUBDIVISION, NORTH WESTLAND. (Bulletin No. 13, New Zealand Department of Mines.) Wellington, 1911. (Exchange.)

HARVARD UNIVERSITY. Reports of the President and the Treasurer of Harvard College, 1910–1911. Cambridge, 1912. (Exchange.)

INFORMATION FROM MINING SCIENCE. A reproduction of certain notes and articles appearing in *Mining Science* during the year 1909. Volume I. Denver, 1910. (Purchase.)

INVESTIGATION OF THE COALS OF CANADA, WITH REFERENCE TO THEIR ECONOMIC QUALITIES: as conducted at McGill University, Montreal, under the authority of the Dominion Government. Volume I. Ottawa, 1912. (Exchange.)

INVESTMENT REGISTRY, LTD. Bond and Debenture Dealing Department. London, n. d.

——— Offer of Capital to Sound Enterprises. London, n. d. (Gift of Investment Registry, Ltd.)

METALLURGY. Volume I.—Introductory. By Herbert Lang. New York, McGraw-Hill Book Co., 1911. Price, $3. (Gift of Publishers.)

[NOTE.—This is the first volume of what promises to be a complete treatise on metallurgy. The preface describes this work as constructed upon a new method, superior to that which has been heretofore followed by the authors of similar treatises; and the author declares also that he has prepared with some care, but will not publish, a bibliography of his subject. These preliminary statements do not favorably impress the reader. Neither students nor practitioners care greatly for the alleged superior "method" of a book on metallurgy. What they value is its contents. On the other hand, both classes welcome the aid of a bibliography which will guide them in pursuing for themselves the investigation of this or that special inquiry. The statement of an author that such research would not be worth while is not a satisfactory substitute for the means of making it. If Mr. Lang's treatise on metallurgy is to be characterized throughout by the omission of bibliographical references and condemnation of previous work, it will be no more than a statement of his personal opinions and conclusions—however valuable these may be.

This particular volume, therefore, will be judged by its contents, quite apart from its "method," and subject to a certain unfavorable prejudice, due to its unnecessary disparagement of existing (especially German) technical literature—concerning which, the reader will be tempted to say that, if he knew more, he would be less confidently contemptuous. It treats, in successive chapters, of The Elements; Ore-Crushing, Ore-Sampling; the Valuing of Ores; Metallurgical Tabulations; the Roasting of Ores; the Smoke of Metallurgical Works, and Sulphur Smoke. Why the subjects of refractory materials, furnace-construction and fuels, should be omitted in an introductory volume on metallurgy, it is fruitless to inquire. An author should be judged by his own plan, and Mr. Lang's plan evidently leaves these subjects out. Concerning the subjects which he deems it logical to consider, he presents a considerable amount of valuable and timely information, and intelligent personal opinion.—R. W. R.]

MINES OF RHODESIA. MINING AND SETTLERS' GUIDE, 1910. Edited by Owen Letcher. Johannesburg, 1910. (Purchase.)

MINING AND GEOLOGICAL INSTITUTE OF INDIA. Member List, 1912. Calcutta, 1912. (Exchange.)

MISSISSIPPI. STATE GEOLOGICAL SURVEY. Bulletin No. 7. Jackson, 1910. (Exchange.)

——— Our Waste Lands. A preliminary study of erosion in Mississippi. By E. N. Lowe. With an appended address on Mississippi's Agricultural Potentialities. By W. J. McGee. Jackson, 1910. (Exchange.)

MYSORE GEOLOGICAL DEPARTMENT. Records. Vol. XI. Mysore, n. d. (Exchange.)

NEW MEXICO. MINE INSPECTOR. Report, 1911. Washington, 1912. (Gift of New Mexico Mine Inspector.)

NEW ZEALAND. DEPARTMENT OF MINES. Bulletin No. 13. Wellington, 1911. (Exchange.)

NEW ZEALAND. OFFICIAL YEAR BOOK, 1911. Wellington, 1911. (Gift of Government Statistician.)

OBSERVATIONS ON THE WEST OF ENGLAND MINING REGION. By J. H. Collins. Plymouth, 1912. (Gift of Author.)

[NOTE.—This book, now separately published, constitutes Vol. XIV. of the *Transactions of the Royal Geological Society of Cornwall*, of which the author is President—a distinction emphasized by sundry others, previously conferred upon him, and by his earlier published works, *A Handbook to the Mineralogy of Cornwall and Devon, The Origin and Development of Ore-Deposits in the West of England, Cornish Tinstones and Tin-Capels, Observations on the Rich Parts of the Lodes of Cornwall, etc.* It is excellent in form and structure. The beautiful typography of its 677 pages, the clearness and pertinency of its numerous illustrations, the fullness and adequacy of its appendixes and index, and the logical arrangement of its contents, are thoroughly satisfactory. Moreover, it is not merely a pretentious compilation, but a critical summary, furnished with such references to other authorities as will enable the reader to follow for himself the clues given, and to test the hypotheses advocated, by the author.

It was high time for the appearance of such a work. Cornwall and Devonshire have had much to do with mining practice and mining theory, dictating for many years the nomenclature and the principles of the art, at least, so far as these were represented in English technical literature. The peripatetic Cornish miner has carried all over the world the terms, the theories and the traditions of his native land. And even in the realm of scientific investigation, where the Germans were perhaps foremost, the observations and conclusions of such authors as Hurwood, De la Beche, Moissenet, and others, concerning the ore-deposits of Cornwall, exercised a dominant influence upon theory. During the last twenty years, however, a flood of light has been shed upon the genesis of ore-deposits by observations and studies in many lands; and it is a highly interesting and important question, what Cornwall and Devon have to say to the new evidence thus presented. Many of the old theories have been modified, restricted, or even disproved. But the old facts are there yet, and the new philosophies must account for them. Mr. Collins appears to be a competent, impartial and conservative judge, and to have taken a comprehensive view.—R. W. R.]

CHRISTOPHER POLHEM. Minnesskrift utgifven af Svenska Tenknologföreningen. Stockholm, 1911. (Gift of Svenska Teknologföreningen.)

PHYSIOGRAPHY AND GEOLOGY OF THE COASTAL PLAIN PROVINCE OF VIRGINIA. (Bulletin No. IV., Virginia Geological Survey.) Charlottesville, 1912. (Exchange.)

REALITÄTEN, ABSTRAKTIONEN, FINGIERUNGEN UND FIKTIONEN IN DER THEORETISCHEN MECHANIK. By O. E. Westin. Stockholm, 1911. (Gift of Svenska Teknologföreningen.)

RECONNAISSANCE OF THE JARBIDGE, CONTACT AND ELK MOUNTAIN MINING DISTRICTS, ELKO COUNTY, NEVADA. (Bulletin No. 497, U. S. Geological Survey.) Washington, 1912. (Exchange.)

ROCK DRILLING WITH PARTICULAR REFERENCE TO OPEN CUT EXCAVATION AND SUBMARINE ROCK REMOVAL. By R. T. Dana and W. L. Saunders. New York, J. Wiley & Sons, 1911. Price, $4. (Gift of Ingersoll-Rand Co.)

[NOTE.—This is, perhaps, the most important general treatise on its theme that has been presented to American and English engineers since the appearance, a generation ago, of Drinker's classic work on Tunneling. Yet the comparison is hardly fair to either work; for they do not attempt to fill similar spheres. The earlier one surveyed an immense field of principles, methods and agents, many of which were, as yet, too little tested to permit critical estimates and limitations of their value. After many years, it remains a thesaurus of information, though it has ceased to be an authoritative guide in practice. This new book presents in smaller compass the technical and economical results of experience, sifted from the mass of vague and speculative experiments, and critically weighed in their

technical and economic relations. Mr. Richard T. Dana, Chief Engineer of the Construction Service Co., is probably to be credited with much of the editorial labor connected with it; but he has been unquestionably assisted and guided by the wide experience and sound judgment of his associate, Mr. W. L. Saunders, President of the Ingersoll-Rand Co., and one of the highest authorities upon rock-drilling, with all branches of which he is both theoretically and practically familiar through his knowledge and training as a professional engineer, and his intimate connection, as the head of a great establishment, with the conditions of practice in all parts of the world. In short, I infer from the title-page that Mr. Davis, in compiling the material, has had command of the information possessed by the Construction Service Co., and that, in his compilation and in his editorial work, he has received the benefit of the vast information and the critical judgment of Mr. Saunders, especially in the department of submarine rock-excavation (Mr. Saunders was at one time engineer in charge of the building of a ship-channel in New York harbor). It seems to me that a stronger "team" could scarcely be desired or imagined. The preface declares that Mr. Davis and his company have no interest, direct or indirect, in any particular rock-drill; and to this declaration I wish to add the further statement that Mr. Saunders, who is avowedly interested, as the head of a great concern manufacturing certain machines, has, to my knowledge, over and over again, in papers and discussions of our Institute, proved himself both able and willing to acknowledge the merits of other machines, and utterly incapable of concealing or distorting facts for the purpose of favoring his own business.

The book treats in successive chapters of Blasting and Explosives; Drilling on Land (seven chapters); Subaqueous Drilling (seven chapters); and Hints and Suggestions for Rock-Drilling and Blasting. Under these heads, the details of the most important modern operations are fully and carefully given.

As I have probably said elsewhere (and certainly have always kept in mind) the value of a book is determined by three questions: What need does it propose to satisfy? Does such a need exist? Has it been met by the book in a satisfactory way? In the present instance, these three questions are to be answered, I think, affirmatively and emphatically, by a work which will be found invaluable to American engineers.—R. W. R.]

SCHACHTABTEUFEN VON HAND. Gesammelte praktische Erfahrungen. By A. Hoffmann. Halle a/S., 1911. (Purchase.)

SOCIÉTÉ DE L'INDUSTRIE MINÉRALE. Table Générale des Matières contenues dans les 15 tomes formant la 4me serie 1902–1911, et dans les Comptes Rendus Mensuels 1902–1911. Saint-Etienne, 1912. (Exchange.)

SOCIETY OF ENGINEERS. Transactions, 1911. London, 1911. (Exchange.)

STATISTICAL ABSTRACT OF THE UNITED STATES, 1911. Washington, 1912. (Exchange.)

STATISTIQUE GÉNÉRALE DE LA FRANCE. Répertoire Technologique des Noms d'Industries et de Professions Français-Anglais-Allemands. Paris, 1909. (Purchase.)

STEAMING TESTS OF COALS AND RELATED INVESTIGATIONS, SEPT. 1, 1904–DEC. 31, 1908. (Bulletin No. 23, U. S. Bureau of Mines.) Washington, 1912. (Exchange.)

SURFACE WATER SUPPLY OF THE UNITED STATES, 1910. Part II.—South Atlantic Coast and Eastern Gulf of Mexico. (Water Supply Paper No. 282, U. S. Geological Survey.) Washington, 1912. (Exchange.)

TASMANIA. GEOLOGICAL SURVEY. The X River Tin Field. (Bulletin No. 12.) Hobart, 1911. (Gift of Tasmania Geological Survey.)

TEMISKAMING AND NORTHERN ONTARIO RAILWAY COMMISSION. The Mining Industry in that Part of Northern Ontario Served by the Temiskaming and Northern Ontario Railway, 1911. Toronto, 1912. (Gift of Temiskaming and Northern Ontario Railway Commission.)

DAS TIEFBOHRWESEN. By Hans Bansen, Berlin, 1912. (Purchase.)

U. S. GEOLOGICAL SURVEY. Bulletin Nos. 497, 499. Washington, 1912. (Exchange.)

——— Geologic Atlas. Bismark Folio. (No. 181.) Washington, 1912. (Exchange.)

——— Water Supply Paper No. 282. Washington, 1912. (Exchange.)

U. S. MINES BUREAU. Bulletin Nos. 10, 23, 36. Washington, 1911, 1912. (Exchange.)

U. S. MINT. Annual Report of the Director of the Mint, 1911, and also Report on Production of Precious Metals, 1910. Washington, 1912. (Exchange.)

USE OF PERMISSIBLE EXPLOSIVES. (Bulletin No. 10, U. S. Bureau of Mines.) Washington, 1912. (Exchange.)

VIRGINIA GEOLOGICAL SURVEY. Bulletin IV. Charlottesville, 1912. (Exchange.

WESTERN AUSTRALIA. Topographical Map of Meekatharra. 1911. (Exchange.)

TRADE CATALOGUES.

INGERSOLL-RAND CO., New York, N. Y. "Arc Valve" tappet rock drills. 16 pages.

STURTEVANT MILL CO., Boston, Mass.

Ring roll mills. 8 pages.

Laboratory crushers. 8 pages.

SULLIVAN MACHINERY CO., Chicago, Ill. Bulletin 63 F. Sullivan continuous coal cutter. 32 pages.

VIXEN TOOL CO., Philadelphia, Pa. Vixen files. 10 pages.

United Engineering Society Library.

GUIDE TO THE TECHNOLOGICAL MUSEUM, SYDNEY, N. S. W. Sydney, 1910. (Gift of Technological Museum.)

ILLUMINATION OF PEOPLE'S GAS BUILDING, CHICAGO. A Paper by Chas. A. Luther, read before the Illinois Gas Association, March 20, 1912. N. p., n. d. (Gift of People's Gas Light & Coke Co.)

PRESENT STATE OF THE EUCALYPTUS OIL INDUSTRY. By Henry G. Smith. N. p., 1911. (Gift of Author.)

TRUTH ABOUT MR. ROCKEFELLER AND THE MERRITTS. By F. T. Gates. N. p., n. d. (Gift of Author.)

VITRIFIED BRICK PAVEMENTS FOR CITY STREETS AND COUNTRY HIGHWAYS. N. p., n. d. (Gift of National Paving Brick Manufacturers' Association.)

GIFT OF ENGINEERING NEWS.

AMERICAN RAILWAY ASSOCIATION. Per Diem. New York, 1910.

AMERICAN WATER WORKS ASSOCIATION. American Standard Specifications for Cast-Iron Water Pipe and Special Castings. N. p., n. d.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS. Proceedings, 1910. New Haven, 1910.

FEDERATION OF TRADE PRESS ASSOCIATIONS IN THE UNITED STATES. Annual Convention, 6th, 1911. Boston, 1911.

GENERAL RAILWAY SIGNAL CO. Catalogue and Price-List. Sections 1–2. Buffalo, 1905.

NEW ENGLAND WATER WORKS ASSOCIATION. Constitution and List of Members, 1909, 1910. Boston, 1909–1910.

PENNSYLVANIA RAILROAD CO. Annual Report, 63d, 1910. Philadelphia, 1910.

RHODE ISLAND. Commissioner of Dams and Reservoirs. Annual Report, 1910. Providence, 1910.

SUPERVISION OF STREET RAILWAYS IN ENGLAND AND PRUSSIA. (Reprinted from Annual Report of the Public Service Commission for the First District of the State of New York, 1908.) Albany, 1909.

TRADE CATALOGUES.

BETHLEHEM STEEL CO., South Bethlehem, Pa. Special structural shapes for buildings and bridges. 40 pages.

DELAVAL STEAM TURBINE CO., Trenton, N. J. DeLaval steam turbines. 117 pages.

GOULDS MFG. Co., Seneca Falls, New York.
Pumps described in ten bulletins. 120 pages.
Pumps and hydraulic machinery. 326 pages.

GREEN FUEL ECONOMIZER Co., Matteawan, N. Y. Green's economizer. 104 pages.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION, Cleveland, Ohio.
The dependable roadway of vitrified brick. 8 pages.
Directions for laying vitrified brick pavement. 24 pages.
Rattler test for paving brick. 8 pages.
Reports on 3d annual convention, Feb., 1912. 74 pages.

MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of April, 1912:

Members.

FULTON, JOHN A., Min. Engr..Melones, Cal.
GALAN, CARLOS F., Mining..................................Rioverde, S. L. P., Mexico.
HENDRICKSON, WILLIAM H., Min. Engr....................Frisco, Beaver Co., Utah.
HOFECKER, CHARLES A., Min. Engr........................Instructed to hold all mail.
JAMES, ULYSSES S., Met. Engr...........................35 Runyon St., Newark, N. J.
JANIN, CHARLES, Min. Engr.......................620 Kohl Bldg., San Francisco, Cal.
KIDDER, SIDNEY J......Genl. Supt., Pittsburg-Silver Peak G. M. Co., Blair, Nev.
LOGAN, JOHN W., Mgr. Steel Wks. Dept., Alan Wood Iron & Steel Co., Conshohocken, Pa.
McNAIR, FRED W..............Prest. Michigan College of Mines, Houghton, Mich.
MERRETT, WILLIAM H., Asst. Prof. of Met., Royal School of Mines, London, "Hatherley," Grosvenor Rd., Wallington, Surrey, England.
MISHLER, RALPH T., Min. Engr....................................Ysabel, Son., Mexico.
RAYMER, GEORGE S., Min. Engr.....................51 Brattle St., Cambridge, Mass.
SCHUETTENHELM, JOHN B., Chem.............East Butte Copper Co., Butte, Mont.
SEDGWICK, ALLAN E., Min. Engr., 2a Calle de Bucaveli 35, Mexico City, Mexico.

Associates.

HALL, WILLIAM J., Asst. Genl. Mgr., Federal M. & S. Co., P. O. Box M, Wallace, Idaho.
JONES, ZECHARIAH, Constructing Engr.............P. O. Box 371, Republic, Wash.
MARSHALL, EMORY M., Student, Mass. Inst. of Technology, 12 Newbury St., Boston, Mass.
WESTLAKE, EMORY H., 2d Vice-Prest., Tennessee Copper Co., 11 Broadway, New York, N. Y.

CANDIDATES FOR MEMBERSHIP.

The following persons have been proposed during the month of April, 1912, for election as members of the Institute. Their names are published for the information of members and associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Council, which has the power of final election.

Members.

William David Burcham, ... Shafter Texas.
Frank D. Carney, ... Steelton, Pa.
Frederick W. Cooke, Jr., ... Paterson, N. J.
Roderic Crandall, ... Rio de Janeiro, Brazil.
Bernard Cunniff, ... Knoxville, Tenn.
Samuel E. Doak, ... Glen Wilton, Va.
Theodore Earle, ... New York, N. Y.

James Clifford Farrant, ... New York, N. Y.
Claude Ferguson, ... Snowden, Cal.
George B. Holderer, ... New York, N. Y.
John Norman Houser, ... Carterville, Mo.
Louis Orrin Howard, ... Greenriver, Utah.
H. S. Jordan, ... Campo Seco, Cal.
Charles R. Kuzell, ... Great Falls, Mont.
Eugene Hooker Leaning, ... Scranton, Pa.
Joseph B. Lower, ... Unsan, Korea.
James Harold McCreery, ... New York, N. Y.
J. C. Maben, Jr., ... Birmingham, Ala.
Harry Marsh, ... Whitehorse, Yukon Ter., Canada.
Charles Grier Morgan, ... Roslyn, Wash.
Harold Simonds Munroe, ... Butte, Mont.
Joseph H. Portugal, ... Salt Lake City, Utah.
Charles Alfred Randall, ... Cobalt, Ont., Canada.
Thomas Skewes Saunders, ... Aire Libre, Puebla, Mex.
Otto Ernest Schiffner, ... Dale, Cal.
Walter D. Schofield, ... Colorado Springs, Colo.
Sydney Smith, ... Haileybury, Ont., Canada.
Matthew Van Siclen, ... New York, N. Y.
Arden Martin Wilson, ... Telluride, Colo.
Clarence Aldro Wright, ... Washington, D. C.

Associate.

Samuel Gibson Martin, ... New York, N. Y.

CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the month of April, 1912. This list, together with the lists published in *Bulletin* Nos. 63 and 64, March and April, 1912, and the foregoing list of new members, therefore, supplements the annual list of members corrected to Feb. 1, 1912, and brings it up to the date of May 1, 1912.

ALLEN, JOHN A., Mgr., Minas del Castaño, Castaño Nuevo, Prov. San Juan, Argentine Republic, So. Am.
ALLEN, ROY H. .... Instructed to hold all mail.
ARMSTEAD, HENRY H. .... 29 Broadway, New York, N. Y.
ASHMORE, ERNEST P. .... P. O. Box 531, So. Porcupine, Ont., Canada.
AUSTIN, ALBERT M. .... 55 Liberty St., New York, N. Y.
AUSTIN, EDWIN A. .... Care Yukon Gold Co., Iditarod, Alaska.
BANKS, JOHN H., Min. Engr. and Chem., Ricketts & Banks, 80 Maiden Lane, New York, N. Y.
BARKER, HENRY A., 315 Edificio Bancario, Ave. Cinco de Mayo No. 32, Mexico City, Mexico.
BARTLETT, WILLIAM S. .... 80 Bishopsgate, London, E. C., England.
BELL, JOHN W., Asst. Prof. Min. Engrg., McGill University, Montreal, Canada.
BOALICH, EDWIN S., Statistician, California State Mining Bureau, Ferry Bldg., San Francisco, Cal.
BOTSFORD, ROBERT S. .... Care O. Lagerfeld, Vladivostok, E. Siberia.
BROWN, CHARLES H., Genl. Mgr., Machine, Automobile & Construction Co., Magdalena, N. M.
BOYT, JOHN, Supt. Alcohol Plant, E. I. du Pont de Nemours Powder Co., Georgetown, S.C.
BRYCE, ROBERT A., Mgr. .... Ross Min. & Mill. Co., Silverton, Colo.
BUTLER, REGINALD H. B., Mgr., U. S. Foil Co., 60 Fernbrook St., Yonkers, N. Y.
CARPENTER, EDWIN E. .... Tonopah, Nev.
CARTER, PALMER, Genl. Mgr., Robinson G. M. Co., P. O. Box 1024, Johannesburg, Transvaal, So. Af.

CAYPLESS, WILLIS S......Am. Smeltg. & Refg. Co., Matehuala, S. L. P., Mexico.
CHAPMAN, JAMES E......Asst. Supt., Mammoth Mine, Mammoth, Shasta Co., Cal.
CHOATE, WAYNE..827 Central Bldg., Los Angeles, Cal.
CHRISTIANSON, ARTHUR O..Groton, Mass.
CLARK, C. DAWES..............................Care Wisconsin Zinc Co., Platteville, Wis.
CLARK, EDWIN M...Whittier, Cal.
CLEMENTS, J. MORGAN....................Room 1811, 20 Broad St., New York, N. Y.
COLE, DAVID..P. O. Box 235, Phœnix, Ariz.
COOPER, JOHN..Apartado 96, Zacatecas, Zac., Mexico.
CORBIN, J. ROSS..1729 Master St., Philadelphia, Pa.
CREMER, FELIX.....Care Cia. Real del Monte y Pachuca, Pachuca, Hid., Mexico.
CROSS, EDWARD O., Mgr., Fostoria Glass Wks. of General Electric Co.,
Fostoria, Ohio.
CRUM, J. RICHMOND..Instructed to hold all mail.
CUMINGS, W. L...409 E. Broad St., Bethlehem, Pa.
CUMMINGS, WILLIAM N..................................1st and Cedar Sts., Glendale, Cal.
CUMMINS, WILLIAM N., Genl. Supt., Red Jacket Cons. Coal & Coke Co.,
Red Jacket, W. Va.
CUNNINGHAM, PARKER H..........................306 N. Jefferson St., New Castle, Pa.
DART, ALBERT C., Cons. Min. Engr...Rock Island, Ill.
DEL MAR, ALGERNON..Bishop, Inyo Co., Cal.
DEVEREUX, JAMES H.......................................60 Broadway, New York, N. Y.
DEVEREUX, W. B...60 Broadway, New York, N. Y.
DOMINIAN, LEON, Care Am. Geographical Society, 156th St. and Broadway,
New York, N. Y.
DOUGLAS, THEODORE...................................80 Maiden Lane, New York, N. Y.
DRAPER, CARL H..................................Apartado 64, San Luis Potosi, Mexico.
DRURY, WALTER M..Mills Bldg., El Paso, Texas.
DUFFUS, JOHN W...Clint, Texas.
DURELL, CHARLES T...P. O. Box 631, Denver, Colo.
FARNUM, HERBERT C.............................622 Hawthorne Blvd., Hollywood, Cal.
FARRELL, JOHN H.........................527 Union League Bldg., Los Angeles, Cal.
FRANK, ALBERT..Instructed to hold all mail.
GIBBONS, CHARLES A., Jr..33 Plain St., Taunton, Mass.
GIRAULT, EDMUNDO......................3a Calle Prim No. 56, Mexico City, Mexico.
GOODLOE, MEADE......San Fernando Bldg., 4th and Main Sts., Los Angeles, Cal.
GORDON, HENRY A........."Ben Lomond," Ranfurly Rd., Epson, Auckland,
New Zealand.
HAAS, J. C..1009 Paulsen Bldg., Spokane, Wash.
HACKETT, WILLIAM H..San Benito, Tex.
HAMILTON, S. HARBERT..250 N. 63d St., Philadelphia, Pa.
HELLMANN, FREDERICK, Cons. Min. Engr., Leggett & Hellman, 60 Broadway,
New York, N. Y.
HOGGATT, WILFORD B.............................110 Beechwood Road, Summit, N. J.
HOLLOWAY, WILFRID S......................."The Valley," Bromly, Kent, England.
HOWARD, JOHN J.......................................389 W. Blockwell St., Dover, N. J.
HUNTER, CHARLES, Piggs Peak Development Co., Ltd., Piggs Peak,
Swaziland, So. Africa.
IMHOFF, WALLACE G...Science Hall, Madison, Wis.
IVES, GLEN P.......Ingeniero de Minas, Casilla 248, Copiapo, Chile, So. America.
JACKMAN, HERBERT E........................133 Dunn Ave., Toronto, Ont., Canada.
JONES, H. EWER...The Lodge, Culmington Road, Ealing, London, W., England.
KATSURA, YOICHI, Mng. Dir., Mining Dept. of Fujita Co., Dojima, Osaka,
Japan.
KAYSER, HENRICH W. F., "Willerden," Chapel St., E. St. Kilda, Melbourne,
Vic., Australia.
KELLOGG, RALPH M., Supt., Ely Cons. Copper Co., P. O. Box 71,
Ruth, via Ely, Nev.
KLEESATTEL, RICHARD.......................................Vanstone Hotel, Seattle, Wash.
LANGLEY, SETH S.................................229 Blatchley Ave., New Haven, Conn.
LAURIE, FRANK C...P. O. Box 1176, Los Angeles, Cal.
LAWRENCE, WILLIS, Genl. Supt., Chosen Mining Co., Ko Sung Mines,
Yeng Byen, Korea.
LECKIE, JOHN E..............................P. O. Box 1555, Vancouver, B. C., Canada.
LEGGAT, ALEXANDER...P. O. Box 15, Butte, Mont.

LEGGETT, THOMAS H., Cons. Min. Engr., Leggett & Hellmann, 60 Broadway, New York, N. Y.
LEONARD, WILLIAM A............Treas., Tremont Nail Co., West Wareham, Mass.
LINTON, ROBERT........................1005 Trust & Savings Bldg., Los Angeles, Cal.
LIPPINCOTT, WARREN B...........................Mariposa Mining Co., Carthage, Mo.
McCASKELL, JASPER A...........................503 Felt Bldg., Salt Lake City, Utah.
McCRERY, CHARLES..................................2825 W. 32d Ave., Denver, Colo.
McDEVITT, JAMES E.................................Care Y. M. C. A., St. Paul, Minn.
MACDONALD, BERNARD...........................Sierra Madre Club, Los Angeles, Cal.
MARSHALL, JAMES J., Mgr. The Gauley Mt. Coal Co., Jodie, Fayette Co., W. Va.
MASON, J. GORDON..Guamo, Oriente, Cuba.
MATHER, THOMAS W..............................308 Chestnut St., Pacific Grove, Cal.
MAY, ALBERT E....................................465 Washington St., Brookline, Mass.
MENTZEL, CHARLES..Instructed to hold all mail.
MESSITER, EDWIN H....................................180 13th Ave., New York, N. Y.
MILLER, JAMES..........................367 Byres Road, Hillhead, Glasgow, Scotland.
MILLS, R. VAN A..20 Union Sq., New York, N. Y.
MITCHELL, GEORGE..............................1467 S. Figueroa St., Los Angeles, Cal.
MORRIS, HENRY C...................................76 Spruceland St., Springfield, Mass.
NAWATNY, WILLIAM F................................425 N. Jackson St., Danville, Ill.
NEBEKER, AQUILA C.............Care Scranton Mines, Lofgreen, Tooele Co., Utah.
NEEL, CARR B., Cons. Engr.............................14 Wall St., New York, N. Y.
NEWBERRY, ANDREW W., Asst. Supt., Mammoth Mountain Mining Co., Isabella, Kern Co., Cal.
PALMER, CHARLES H., JR ....Asst. Mgr., So. Nevada Min. Co., Las Vegas, Nev.
PEARSON, FRED S..........................17th floor, 115 Broadway, New York, N. Y.
PHILLIPS, WALTER I......................................Silverbell, via Red Rock, Ariz.
PLATT, EDWIN H..730 Symes Bldg., Denver, Colo.
PORTER, J. McD....................................A. D. Jones Bldg., Spokane, Wash.
PROBERT, FRANK H., Cons. Engr. and Min. Geol., 314 Central Bldg., Los Angeles, Cal.
PROUT, WILLIAM M.....................Claremont Rd., Redruth, Cornwall, England.
RAMBO, WILLIAM C. J., Rambo-Bignell Engrg. Co., 923 First Natl. Bk. Bldg., Denver, Colo.
RICE, EUGENE R.................Southwestern Miami Development Co., Miami, Ariz.
RICE, GEORGE S., Cons. Engr.........................154 Nassau St., New York, N. Y.
RICKARD, R. D......................3728 Grand Central Terminal, New York, N. Y.
RICKETTS, DR. P. DE P., Min. and Met. Engr., Ricketts & Banks, 80 Maiden Lane, New York, N. Y.
RODGERS, CHARLES E...Instructed to hold all mail.
SAHLIN, ROBERT C., Care Tata Iron & Steel Co., Sakchi, via Kalamati, B. N. R., India.
SEARLES, LINN W., Cons. Engr............201 Woodward Bldg., Birmingham, Ala.
SMITH, ALEXANDER HENRY...........................South Porcupine, Ont., Canada.
SMITH, J. WILLIAM, Chem. Engr......43 White Memorial Bldg., Syracuse, N. Y.
STÄHLER, H......Bergwerksdirektor, Heinitzgrube, by Beuthen, O. S., Germany.
STANFORD, RICHARD B., Min. Engr. and Geol., 206 Metropolitan Bank Bldg., New Orleans, La.
STERNFELD, THEODORE, Treas., Am. Metal Co., Ltd., 52 Broadway, New York, N. Y.
STEVENS, BLAMEY.........................Rencon Mine, Temascaltepec, Mex., Mexico.
STEWART, ARTHUR J...Cottage Grove, Ore.
STEWART, JOHN B......Care C. L. Constant & Co., 42 New St., New York, N. Y.
STOFFEL, PAUL X., Min. Engr......Apartado 112, Gomez Palacio, Dur., Mexico.
SWANQUIST, GUSTAVUS A.....................135 W. Carr Ave., Cripple Creek, Colo.
TAYLOR, HENRY B...................................417 W. 121st St., New York, N. Y.
THOMPSON, MALCOLM M., Care Duncan Fox & Co., Antofagasta, Chile, So. Amer.
TOBEY, HORACE P.................Prest., Tremont Nail Co., West Wareham, Mass.
TONKIN, JOHN...Edwards, St. Lawrence Co., N. Y.
TORRES, FRANK L..803 Austin St., El Paso, Tex.
VARDEN, RICHARD A., Gt. Perseverance Gold Mine, Kalgoorlie, West. Australia.
WAUGH, PERCIVAL B., Birichi Tin Co., Ltd., Naragata, No. Nigeria, West Africa.
WEDDLE, JOSEPH H.................................100 William St., New York, N. Y.
WEIGALL, ARTHUR R., Care Commercial Banking Co. of Sydney, Birchin Lane, Lombard St., London, E. C., England.

WHITAKER, ORVIL R., Min. Engr..............932 Equitable Bldg., Denver, Colo.
WILKINSON, WILLIAM F.......................Trevu, Camborne, Cornwall, England.
WILLIAMS, RALPH B..................................96 High St., Newburyport, Mass.
WILMOT, H. CLIFFORD..........Care Colorado Mining Co., Aroroy, Masbate, P. I.
WISHON, WALTER W., Cons. Engr.........194 Alexandria Ave., Los Angeles, Cal.
WOLF, ALBERT H.........................Room 1148, 10 S. La Salle St., Chicago, Ill.
WOLF, HARRY J......................................Stanley Mines, Idaho Springs, Colo.
WORTH, JOHN G...27 William St., New York, N. Y.
WRIGHT, HERBERT B.............Pocahontas Cons. Collieries Co., Pocahontas, Va.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address of Record, from which Mail has been Returned.
Baxter, Francis K., Jr.,	423 Wells Fargo Bldg., San Francisco, Cal.
Cook, Edward H.,	Minas Birimoa, S. A., Birimoa, via Canelas, Dur., Mexico.
Danforth, A. H.,	Cotopaxi, Colo.
Fitzgerald, Thomas F. M.,	211 Sharon Bldg., Salt Lake City, Utah.
Furness, James W.,	Coffee, Trinity Co., Cal.
Geiger, Arthur W.,	Cortez, via Beowawe, Nev.
Hagemann, Wilhelm,	Metates, via Tepehuanes, Dur., Mexico.
Higgins, Edwin,	Randsburg, Cal.
Hollis, R. W.,	Silverton, Colo.
Johnson, Dion L.,	325 Water St., Pittsburg, Pa.
Lampshire, John O.,	Vulture Mine, Wickenburg, Ariz.
Leavell, John H.,	Buffalo Mine, Cobalt, Ont., Canada.
Le Noir, Frank H.,	Box 16, Mt. Bullion, Cal.
Levensaler, Lewis A.,	Cordova, Alaska.
McDougall, Wallace D.,	20 Bedford Place, Russell Sq., London, Eng.
Moore, Roy W.,	P. O. Box 48, Velasco, Tex.
Munroe, Martin,	Bengal Coal Co., Murulidih, Mohada, B. N. Ry., Bengal, India.
Nelson, D. W. C.,	Baker City, Ore.
Nobs, Frederick W.,	Negociacion Minera Santa Maria de Guadalupe y Anexas, S. A., Minillas, Zac., Mexico.
Pearson, William R.,	628 W. 114th St., New York, N. Y.
Perks, Harry B.,	419 Board of Trade Bldg., Portland, Ore.
Peterson, Frank,	H. W. Hellman Bldg., Los Angeles, Cal.
Rathborne, Merwyn R. W.,	Amargosa, via Las Vegas, Nev.
Rhew, James W.,	Cia. Minera y Exploradora de Ventanas, S. A., Ventanas, Dur., Mex.
Sheldon, Waldo,	Urique, Chih., Mexico.
Short, Frank R.,	Carson City, Nev.
Thornton, Edward T.,	Apartado 30, Matehuala, S. L. P., Mexico.
Twynam, Henry,	O. K. Copper Mine, Cairns, No. Queensland, Australia.
Watson, Ralph W.,	Calloo, Utah, Clifton Mail box.

NECROLOGY.

The deaths of the following members were reported to the Secretary's office during the month of April, 1912:

Date of Election.	Name.	Date of Decease.
1883.	*Coryell, Torbert,	April 18, 1912.
1883.	*Lathrop, William A.,	April 12, 1912.
1893.	*Sjöstedt, Ernst A.,	April 15, 1912.

* Member.

BIOGRAPHICAL NOTICES.

Correction.

In my Biographical Notice of T. Guilford Smith, published in the April *Bulletin*, I spoke of the Gen. Pleasonton, with whom Mr. Smith was associated in the development of the block-coal of Indiana, as "Franklin B. Gowen's Chief Engineer." This error, due to my hasty confusion of names, I now beg to confess and correct. Mr. Gowen's Chief Engineer was Gen. Henry Pleasants (not Pleasonton), a distinguished officer in the Union Army, Colonel of the 48th Regiment, Penna. Vols., who conceived and directed the construction of the famous mine under the fortifications at Petersburg, Va., and, in recognition of his services, was brevetted as Brigadier-General by President Lincoln. After the war he became Chief Engineer of the Reading Coal & Iron Co. He joined the Institute in 1872, remained a member until his death, in 1880, and was much esteemed and beloved by his fellow-members, besides receiving their professional recognition of his technical ability and courage—the latter having been exhibited especially in the sinking of the two vertical shafts near Pottsville, described by Eckley B. Coxe.[1] My friendly recollection of Gen. Pleasants led me to a hasty confusion of his name with that of the distinguished Union veteran, Maj. Gen. Alfred Pleasonton, who, after the war, became interested in Indiana coal-mining, and with whom Mr. T. Guilford Smith was, for a time, associated.

John Walter Young was born Sept. 26, 1855, at Brooklyn, N. Y., and received his degree as a civil engineer from the Brooklyn Polytechnic Institute. From 1873 to 1890 he worked for mining and ore-reducing companies in Montana, Colorado, British Columbia, etc.

The following sketch of his life, prepared by Mr. W. J. Chalmers, a member of the Institute, with whom he was long associated in business, is taken from the *Mining and Engineering World* of Jan. 20.

Mr. Young went to Leadville, Colo., in 1878, and, realizing the great opportunities there in the metallurgical profession, he from then on gave his whole time to the study of problems connected with the treatment of ores.

He remained for a couple of years at Leadville, where he benefited largely through association with such men as Eilers, Schlapp, Hahn, and others. From Leadville he went to Montana, where he became associated with Wm. B. Frue, inventor of the Frue vanner, and with Walter McDermott, a well-known metallurgist, now managing director of Fraser & Chalmers, Ltd., London.

While in Montana, Mr. Young was called to various Western States, Mexico, and other foreign countries, on important mining transactions, involving the treatment of ores and the development of properties. While residing in Helena, he became associated with Fraser & Chalmers, the well-known mining machinery manufacturers of Chicago, as Western Sales Manager, with headquarters in Helena.

In 1901, when Fraser & Chalmers became an integral part of Allis-Chalmers Co., Mr. Young was called to New York as Vice-

[1] A New Method of Sinking Shafts, *Trans.*, i., 261 (New York meeting, May, 1872).

President of Fraser & Chalmers, to which position he had gradually risen from Sales Manager, and was also made Secretary of Allis-Chalmers Co. Later, he was appointed general European Sales Engineer for the same company, with headquarters in London, remaining there five years. He resigned his position in 1907 to become associated with Chalmers & Williams, Inc., Chicago Heights, Ill., manufacturers of mining machinery, as Vice-President, with whom he was actively interested up to the time of his death.

During the time of his connection with Fraser & Chalmers, the company's trade had extended throughout the world, and it was found expedient to send a capable and trustworthy representative to visit the important mining-camps in Australia, India, China, the Straits Settlements, and Japan. The result of this trip around the world by Mr. Young was a largely increased business and many new connections for his company.

Among some of Mr. Young's more important achievements while with Fraser & Chalmers were the installation of a plant for the treatment of gold-ores in Greece; a complete smelting and copper-converting plant for the Mt. Lyell Co. in Tasmania; and a similar plant for the Boleo Co. in Lower California. In the early days of the Anaconda Mining Co., Mr. Young secured the larger portion of the business of J. B. Haggin, Marcus Daly, George Hearst, and associates.

Probably no one connected with the mining industry had a larger circle of friends throughout the world. Scarcely a mining engineer of reputation but knew him and admired him for his sterling worth and broad knowledge of mining, and the friendships existing between these men were very close, as was witnessed by the numerous telegrams of condolence received by the family.

He was a member of the American Institute of Mining Engineers (which he joined in 1874), the Montana Society of Engineers, the Engineers' Club of New York, and a number of other clubs.

Mr. Young died Jan. 14, 1912, at his home in Evanston, Ill.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Geology and Ore-Deposits of the Silverbell Mining-District, Arizona.

BY C. A. STEWART, MOSCOW, IDAHO.

(New York Meeting, February, 1912.*)

CONTENTS.

* Presented in oral abstract at a meeting of the Spokane Local Section of the Institute, Nov. 24, 1911.

I. Introduction and General Statement of Results.

The field-work upon which this paper is based was done in the summer of 1910, and was made possible by the courtesy of the Imperial Copper Co., which gave me access to its property. For their kindness in this respect I wish to express my thanks to W. F. Staunton and Meade Goodloe. Moreover, B. F. Smith and G. B. Gentry, mining engineers in the employ of the company, gave invaluable assistance by placing maps, etc., at my disposal, and by discussing with me the problems of the district; and it is a great pleasure to acknowledge this indebtedness to them. In order that the significance of some of the details that follow may be better appreciated at first reading, a general outline of the conclusions reached is given here.

In the Silverbell mining-district a series of Palæozoic limestone blocks is completely surrounded by post-Palæozoic igneous rocks, intruded in the following order: alaskite, alaskite-porphyry, biotite-granite, andesite, and quartz-porphyry. The biotite-granite is believed to represent a differentiation of the magma from which the alaskite-porphyry came; and this conclusion has an important bearing on the origin of the ores. The intrusion of both alaskite-porphyry and biotite-granite was followed by the emission of magmatic waters, which sericitized and silicified the alaskite-porphyry and granite, and produced in the limestone, by the addition to it of silica, iron, and alumina, great masses of garnet, quartz, and wollastonite. Following close upon these solutions came metal-bearing magmatic waters, which impregnated porphyry, granite, and alaskite with cupriferous pyrite, and deposited in the garnet zones chalcopyrite and copper-bearing pyrite that make important bodies of contact-metamorphic ores. Secondary enrichment has taken place in the disseminated ores in the igneous rocks, raising their copper-content to 2 per cent. in some cases, and extensive drilling has been undertaken to block out these deposits. East of the contact-metamorphic deposits there is a fissure-vein of lead-silver ore in the quartz-porphyry. This rock is distinctly younger than the alaskite-porphyry and the granite; and the lead-silver ores belong, therefore, to a period of mineralization distinctly later than the copper-deposition.

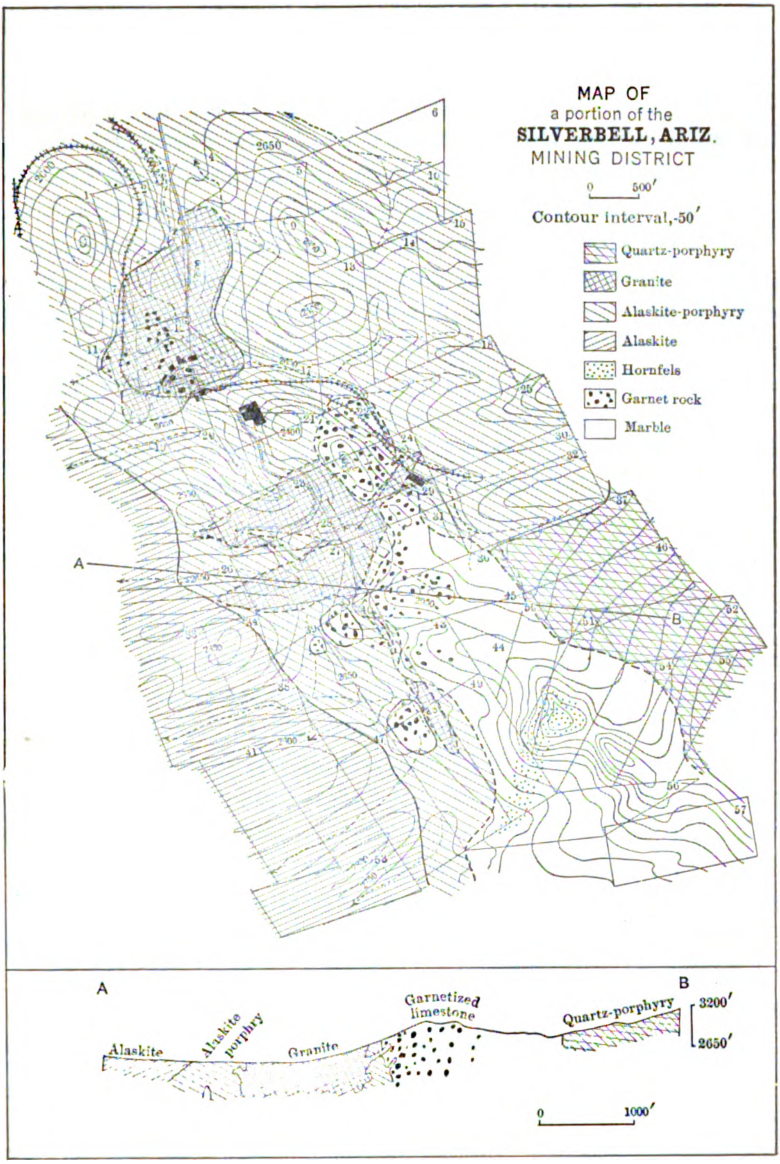


FIG. 1.—MAP OF A PORTION OF THE SILVERBELL MINING-DISTRICT, WITH GENERALIZED SECTION ON LINE A–B.

KEY TO CLAIMS AS NUMBERED IN FIG. 1.

1 Jesuit.
2 Pope.
3 Prince of Wales.
4 Columbia.
5 Ruby.
6 Bobby.
7 Peerless.
8 Belle.
9 John F.
10 Eugene.
11 Daisy.
12 Leslie.
13 Billy.
14 Klondike.
15 Northern Star.
16 Wilson.
17 Black Eagle.
18 Red Ridge.
19 Bay State.
20 Maggie.
21 Wedge.
22 Imperial.
23 Florence.
24 Southern Beauty.
25 Enterprise.
26 Hilda.
27 Yankee.
28 Spike.
29 Union.
30 Northern.
31 Comet.
32 Alliance.
33 Oversight.
34 Frank B.
35 Hamilton.
36 Page.
37 Protection.
38 Detroit.
39 Sampson.
40 Mammoth.
41 Taft.
42 Olympia.
43 Mountain View.
44 Wedge.
45 Fraction.
46 Chance.
47 Queen.
48 Prospector.
49 Emerald.
50 Confidence.
51 Silverbell.
52 Long Shot.
53 Pima.
54 Black Daisy.
55 Herbert.
56 Mollie.
57 Murray.

The chief points of general interest in the district are the peculiar relationships existing between the alaskite-porphyry and the granite; the occurrence of quartz dikes; the shape of the garnet masses, which suggests formation by some process other than replacement; chemical evidence, confirming the view that contact-metamorphic garnets are not usually the result of recrystallization; and the establishment of a rather definite time for the emission of magmatic ore-bearing solutions, which have continued after the intrusion. Of economic importance are the establishment of the distinctly later age of the lead-silver deposits; the recognition of the importance of both granite and alaskite in the formation of the contact-ores; and the interpretation of some of the facts found in prospecting the disseminated deposits.

II. Location, Topography, and History.

The Silverbell mining-district is situated in the western part of the Silverbell mountains, in Pima county, Arizona, about 40 miles west of Tucson, and 20 miles south of Red Rock, on the main line of the Southern Pacific railroad, with which station it is connected by the Arizona Southern railroad, a standard-gauge road built and controlled by the Imperial Copper Co.

The Silverbell mountains form the northern spur of the Roskruge range, one of that series of low but rugged mountain-chains with NE–SW. trend which rise sharply out of the flat, barren wastes of the Arizona desert region. These mountains are the stumps of larger hills which have been cut down by erosion, the detritus of this erosion having in part filled the intervening valleys and produced the level plains of the desert. Elevations in the Silverbell district vary from 2,500 to 4,000 ft.; and the climate, although somewhat cooler than that of the sandy stretches around Red Rock, is dry and hot. The vegetation is typical of the desert—mesquite and various forms of cacti predominating.

Within the Silverbell district itself the topography is very rugged, as indicated on the map, Fig. 1. The elevations on this map were determined with an aneroid and are therefore approximate. The topography is also shown in Figs. 2, 3, 4, and 5.

In general, the mountains of the Arizona desert region are similar to the Basin ranges of Gilbert,[1] which represent lines of monoclinal or, more rarely, anticlinal folding.[2] In the limited area covered by me, however, only late intrusive rocks with a few detached blocks of sediments were seen; and it was impossible to gather any data as to the mountain structure. It is therefore uncertain whether the Silverbell mountains represent an intrusive area in a typical Basin range, or whether the whole Roskruge is the remnant of a series of resistant igneous rocks.

For nearly 50 years, prospectors have been attracted to this region by the heavy, black, copper-stained garnet outcrops. In the early days several small but rich pockets of lead-silver ores were opened up. These were, however, soon exhausted, and intermittent attempts were made to work the copper-ores associated with them, but with no success until 1903.

At this time the Imperial Copper Co. was organized as successor to the Silverbell Mining Co., and began systematic mining and development on its property of some 60 claims, which included the Old Boot mine, first opened in 1865. A railroad was built to Red Rock; in 1904, more than 3,000,000 lb. of copper was produced; and this amount increased steadily to 1909, when the total production was 11,000,000 lb. The Old Boot mine has been renamed the Mammoth, and now has a 700-ft. vertical and a 900-ft. inclined shaft, Fig. 6. Two other mines, the Union, with a 450-ft. vertical shaft, Fig. 7, and the Billy, 350 ft. deep, have also been opened.

At first the ore was shipped to the Copper Queen works at Douglas for reduction; but in 1908, blast-furnaces and converters capable of handling 800 tons of ore a day were completed at Sasco, on the Arizona Southern railroad, 5 miles north of Silverbell.

In August, 1910, the company stopped mining and shut down the smelter, because of the depression and uncertainty in the copper industry. It is, however, continuing development-work in the contact-ores, and churn-drill exploration of the disseminated deposits.

---

[1] Ransome, F. L., *Professional Paper No.* 12, *U. S. Geological Survey* (1903).

[2] Wheeler's *Report on Geographical and Geological Surveys West of the One Hundredth Meridian*, vol. iii. (1875).

III. Description of the Rocks.

1. *Altered Sediments.*

Distribution.—Limestone, now changed to marble, and some peculiar siliceous rocks, considered as altered impure phases of the same formation, are found along a NW–SE. line, in irregular blocks completely surrounded by igneous rocks. The shape and distribution are shown in Fig. 8. The largest block is nearly 2 miles long, and has a maximum width of more than 2,000 ft. This "lime belt," as it is locally called, forms a steep ridge, because of the resistance offered to erosion by the peculiar siliceous rock (described below), or by the garnetized portions. No other sediments were found in the region visited; and these isolated blocks of marble appear more like fragments swamped in an intrusive than like members of a sedimentary series in place.

Description.—The typical marble is white or white with gray bands and coarsely crystalline, the grains averaging 0.25 in. in diameter. Except in the garnet zones it is fairly pure, and in it are found tabular masses of black marble often several hundred feet long, which represent beds of more carbonaceous material. The complete destruction of all continuous bedding, and the general "stewing up" that the whole mass has undergone, are shown by the irregular way in which these black patches are scattered through the white marble. Knots of quartz, probably formerly flint nodules, and stringers and lenses of finer-grained, more siliceous limestone are sometimes found.

Capping the ridge in the Silverbell and Black Daisy claims, and forming a buttress on the SW. side of the hill, is a puzzling rock, thought in the field to be a rhyolite, but appearing upon further study to be the result of recrystallization and silicification of a clay-quartz bed in the original sediments. In the hand-specimen this rock is gray, blue-gray, or greenish, exceedingly tough and hard, breaks with a conchoidal fracture, and is as fine-grained as a novaculite. On the weathered surface, it sometimes shows a parallel streaking that might be flow-structure. Microscopically, the rock is a very fine mosaic of quartz and possibly feldspar, with varying amounts of chlorite, epidote, and diopside, and occasional garnet, Fig. 9. The

chlorite, diopside, and epidote are always microscopic in size, often too small for positive identification. They may be only accessories, or may make up the greater part of the rock, and, when arranged in bands, account for the "flow-line" appearance of the weathered material. This rock, found in irregular masses in the underground workings, is known to the miners as "altered lime." At the surface it often shows a dark brown or black "varnish," and, because of its resistance, stands out like the garnet rock, for which it is mistaken from a distance. Although lacking the knotted, spotted appearance of many rocks formed by the metamorphism of shales, this rock is best classed as a hornfels, and will be spoken of as such hereafter.

Age.—No determinable fossils were found in these rocks, but there were seen in the marble some bits of clearer calcite which, from their shape, were undoubtedly remains of organisms. To a vivid imagination, the general outline, in some instances, suggested brachiopods. Evidently basing his statement upon knowledge of the surrounding country, W. P. Blake has called this marble Carboniferous,[3] and the same opinion is held by Prof. C. F. Tolman, Jr.,[4] the present Territorial Geologist, who notes Carboniferous strata in the Silver hills to the north.[5]

2. *Alaskite.*

Distribution.—This rock forms all of the Silverbell mountains southwest of the lime belt, being bounded on the northeast as shown in Fig. 8, and disappearing to the south, west, and north under the detrital material of the desert out of which these mountains rise abruptly. The area thus exposed is roughly 10 square miles.

Description.—The alaskite is a coarse, even-grained rock consisting of quartz and feldspar, with practically no dark silicates. The weathered material seen on the hills is usually dark red, and because of the projection of the knobs of quartz has a rough and jagged surface, with an appearance of excessively coarse grain recognizable from a considerable distance. The

[3] Report of Governor of Arizona for year ended June 30, 1904, pp. 66–72.

[4] Private communication.

[5] *Mining and Scientific Press*, vol. xcix., No. 22, pp. 710 to 712 (Nov. 27, 1909).

fresh rock is light gray, and the actual diameter of the grains is seldom more than 0.5 cm. Microscopic examination shows that the feldspar forms approximately two-thirds of the rock and is largely orthoclase, the subordinate plagioclase being nearly pure albite. Zircon and magnetite (probably titaniferous) are unimportant accessories, and an occasional flake of biotite is seen. The dusty appearance of the quartz is characteristic, and much of the rock shows cupriferous pyrite or its decomposition-products, which will be further discussed under "Disseminated Ores." Some of the gulches showed patches of rock rich in hornblende or biotite; but the general lack of minerals other than quartz and feldspar justifies the name of alaskite.

Of important economic significance are the parallel, nearly vertical joints of a NE–SW. strike that occur rather generally, but still somewhat irregularly, throughout this alaskite, especially along the contact with the alaskite-porphyry. They are not typical prismatic joints of an igneous rock, nor do they seem connected with displacement; they may be due to stresses produced by later intrusives.

Aplite dikes from 1 to 12 in. in thickness, consisting of fine-grained quartz and feldspar, were found all through the alaskite, but particularly along the contact. They are evidently slightly later intrusions from the same magma; for they are in some cases found grading into coarse alaskite.

3. *Alaskite-Porphyry.*

Distribution.—The alaskite-porphyry is intimately associated with the ore-deposits, and is best developed in the northern portion of the lime belt, where it forms a great stock bounded on the south, east, and west, as shown in Fig. 8, and disappearing beneath the detrital material of the desert to the north. Its extent NE. beyond the Metallic Bobby claim (6) is unknown. Southwest of the main limestone block, it pinches out to a thin streak; but at the SE. end of this block on the Young America property it forms an appreciable mass limited by quartz-porphyry, alaskite, limestone, and the detrital plains of the desert.

The contact between the limestone and the alaskite-porphyry is in some places obscured by a thin layer of float, and by the

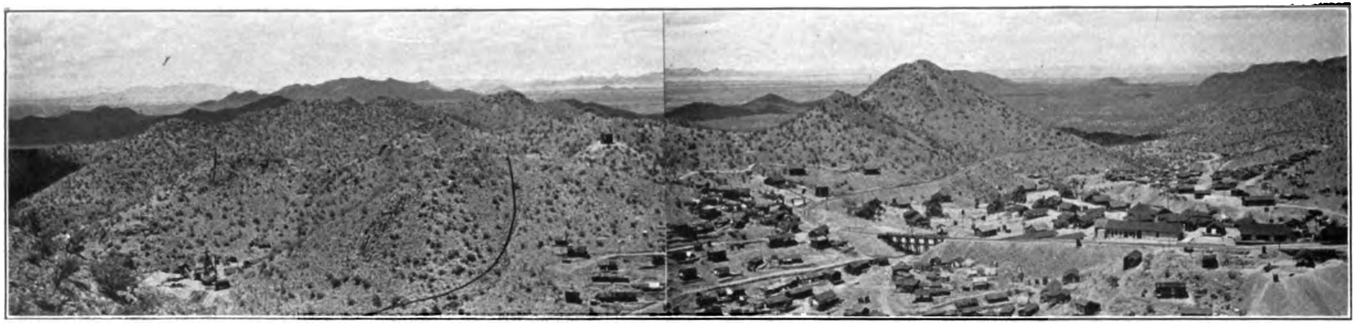
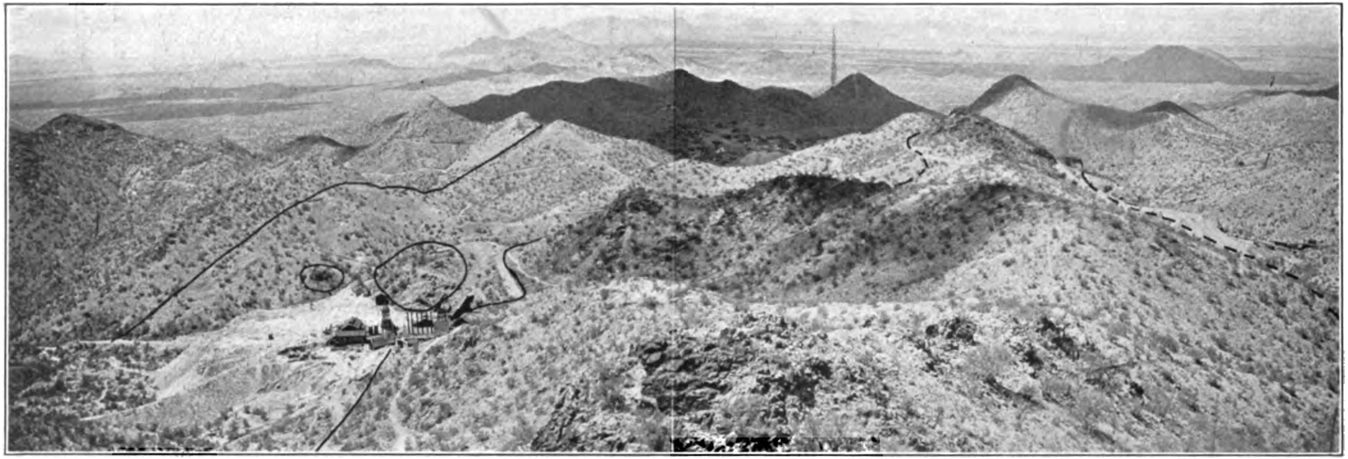


FIG. 2.—LOOKING NORTH FROM TOP OF HILL IN BAY STATE CLAIM (19).

Alaskite on the west; alaskite-porphyry and granite on the east. This view shows the northern part of the Silverbell mountains rising out of the desert.



Alaskite-porphyry. Marble and garnet rock.

FIG. 3.—LOOKING NORTHWEST FROM TOP OF RIDGE IN SILVERBELL CLAIM (51).

Note rough outcrops of coarse alaskite on hills to the west; inclusions of garnet rock in alaskite-porphyry; black garnet cappings show in middle distance and at northern end of marble block; jagged rock in center foreground is hornfels.

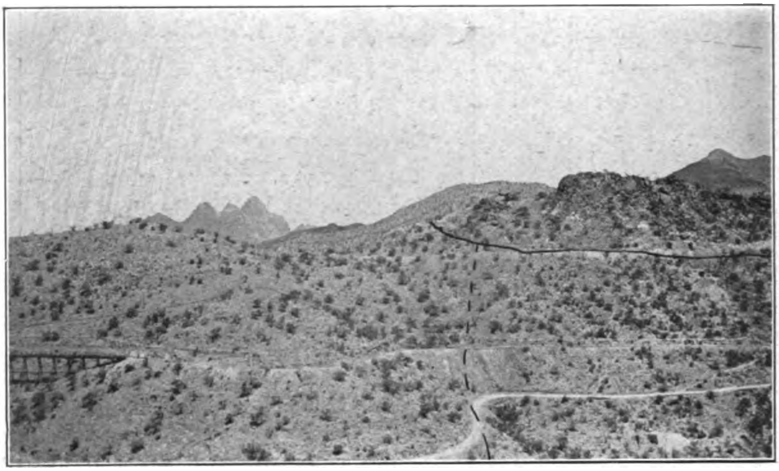


FIG. 4.—LOOKING EAST IN THE BLACK EAGLE-IMPERIAL CLAIMS (17, 22).

At the right is black garnet rock; lower right is granite-porphyry, and left is alaskite-porphyry.

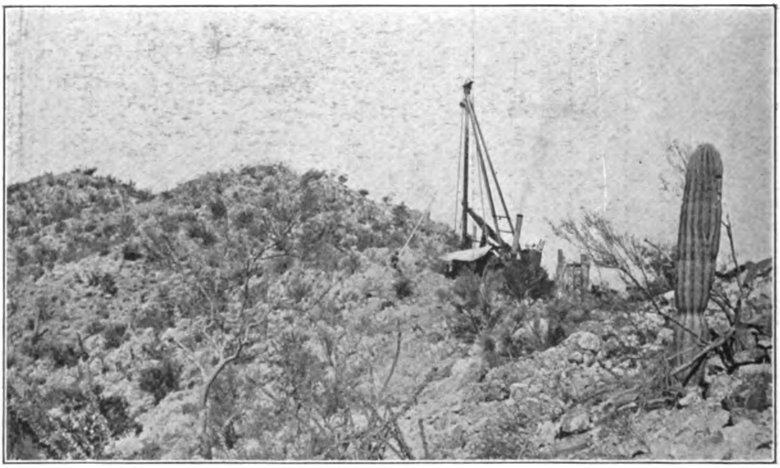


FIG. 5.—PROSPECTING FOR DISSEMINATED ORE IN THE ALASKITE.

The picture also shows the rough character of the hills of this rock.

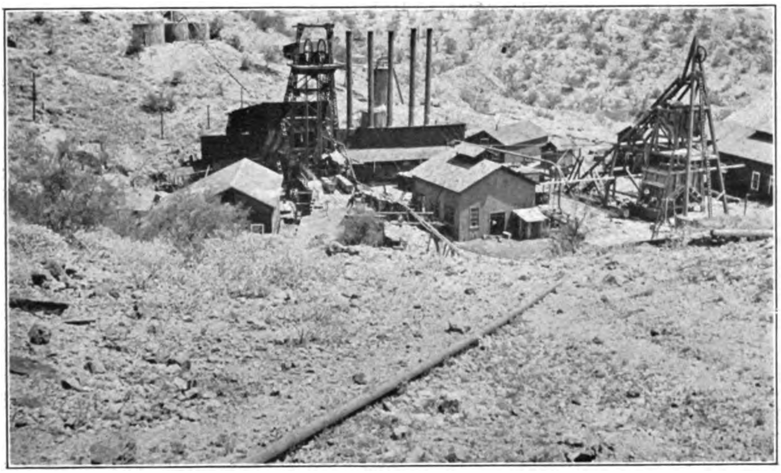


FIG. 6.—MAMMOTH VERTICAL AND INCLINE SHAFTS.

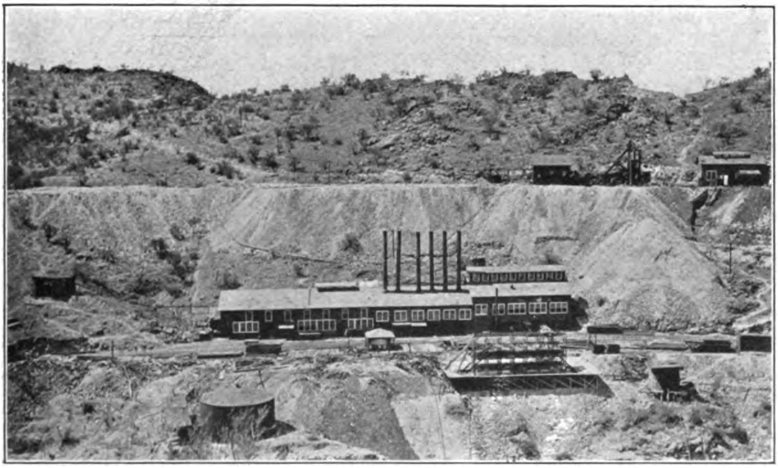
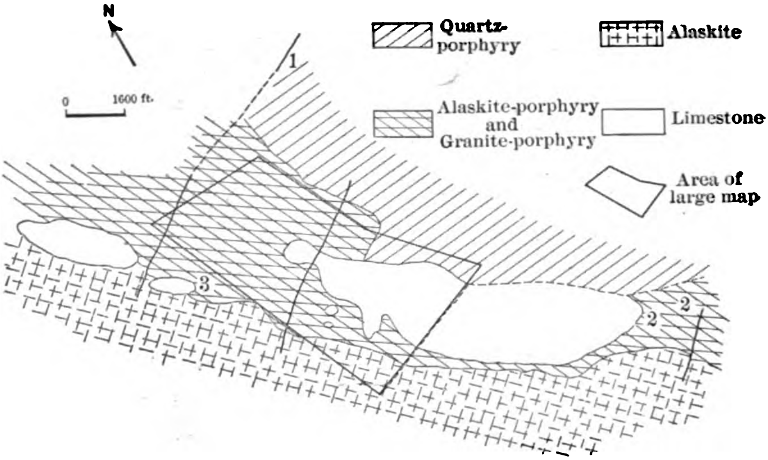


FIG. 7.—UNION SHAFT AND POWER-HOUSES.

Dark rock in upper left-hand corner is garnetized limestone; depression at right of shaft is dike of granite-porphyry; alaskite-porphyry in foreground, contact with lime covered by dump.



1. Lead-Silver Prospect. 2. Young America Property. 3. El Tiro Shaft.

FIG. 8.—SKETCH-MAP SHOWING GENERAL RELATIONSHIPS IN THE SILVERBELL MINING-DISTRICT.

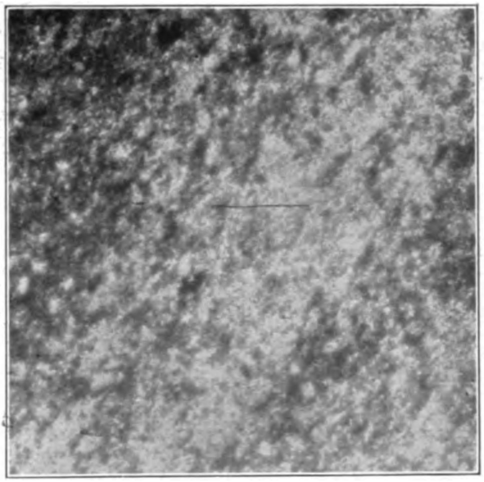


FIG. 9.—HORNFELS. ORDINARY LIGHT. × 100 DIAMETERS.

The white is quartz and probably some feldspar; the gray is chlorite, epidote, and diopside.

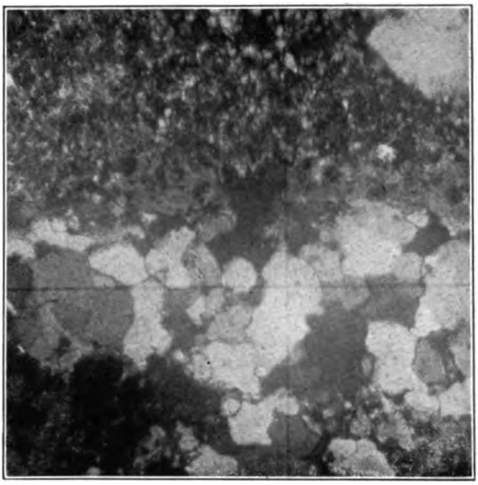


FIG. 10.—SILICIFIED ALASKITE-PORPHYRY. CROSSED NICOLS. × 50 DIAMETERS.

The felty mass in the upper left-hand corner is unaltered ground-mass; all of the rest of the slide is secondary quartz.

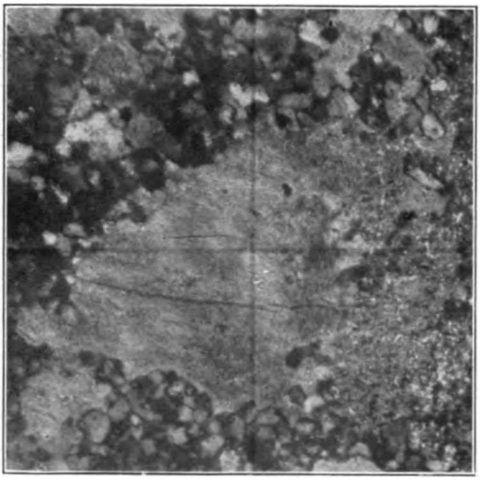


FIG. 11.—SILICIFIED ALASKITE-PORPHYRY. CROSSED NICOLS. × 100 DIAMETERS.

In hand-specimen this rock was a "quartzite," not distinguishable from a specimen of a quartz dike. All of the above picture is secondary quartz except the dusty fragment in the center, which is a feldspar phenocryst in the process of silicification.

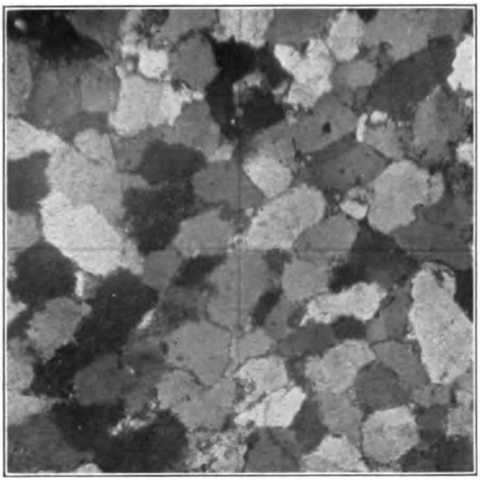


FIG. 12.—QUARTZ DIKE. CROSSED NICOLS. × 50 DIAMETERS.

All of the grains are quartz.

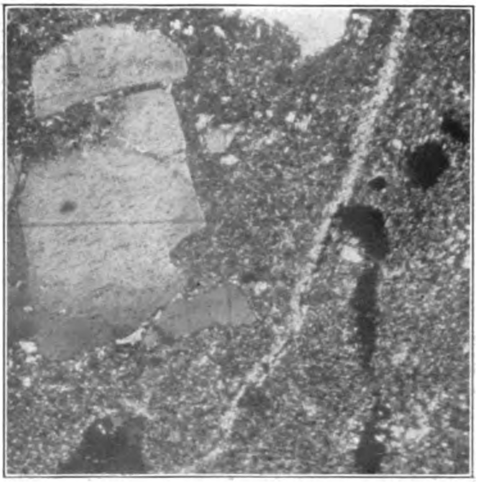


FIG. 13.—ALASKITE-PORPHYRY. CROSSED NICOLS. × 50 DIAMETERS.

This is as near unaltered alaskite-porphyry as was found. The phenocrysts are primary quartz; ground-mass shows some sericite, and a vein of sericite is seen.

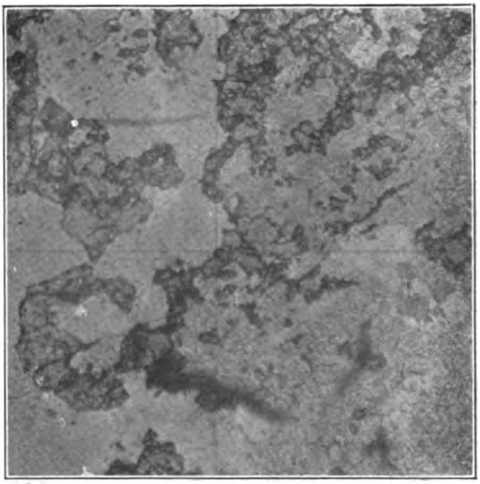


FIG. 14.—GARNET REPLACING ALASKITE-PORPHYRY. ORDINARY LIGHT. × 50 DIAMETERS.

Mineral in high relief is garnet.

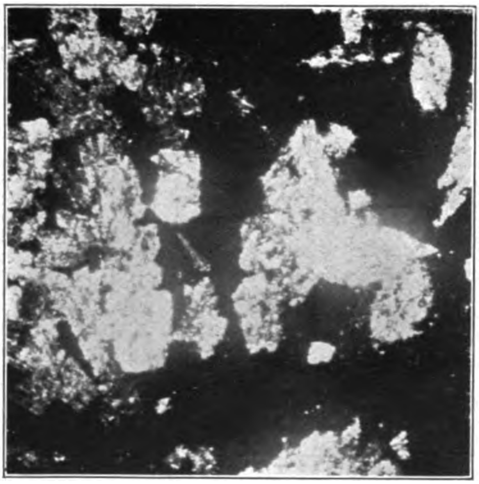


FIG. 15.—GARNET ROCK. CROSSED NICOLS. × 50 DIAMETERS.

Black is garnet; white and gray, wollastonite.

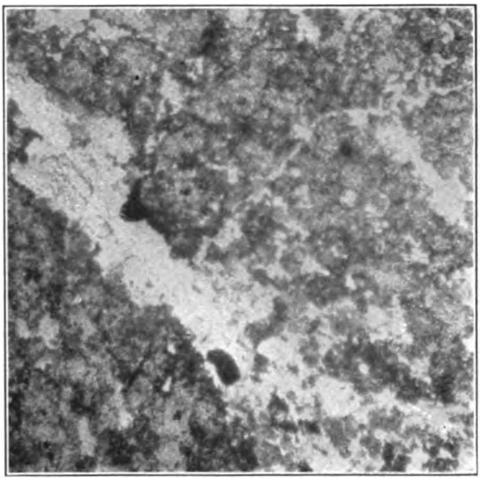


FIG. 16.—LEAN ORE. ORDINARY LIGHT. × 50 DIAMETERS.

Rough material is garnet; white is quartz with a little calcite; the black spots in the veinlet are pyrite. This is the commonest relation of these minerals and shows the later genesis of quartz and ore.

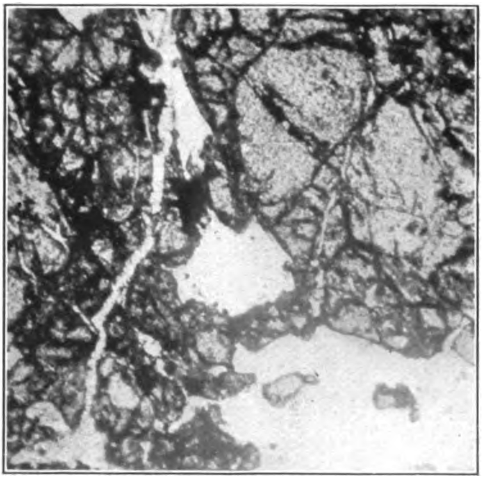


FIG. 17.—GARNET AND LATER QUARTZ. ORDINARY LIGHT. × 50 DIAMETERS.

Note suggestion of porous garnet mass filled with quartz.

puzzling character of the altered rocks, and could, therefore, be only approximately located on the map; but the general relationships are believed to be accurately shown.

Description.—The alaskite-porphyry shows considerable variation, but the generally acidic character of the rock and the lack of dark silicates seem to justify this name, which was first given by C. F. Tolman, Jr.[6] As found in the field it is most often a buff-weathering, fine-grained rock, apparently made up of minute grains of quartz and feldspar (from 1 to 2 mm.) set closely in a dull white ground-mass. The feldspar is milky white, and so dulled by alteration that it offers little contrast to the ground-mass. It is very likely largely orthoclase; and what little plagioclase is present is probably not more basic than oligoclase. The determination of the feldspars, however, is unsatisfactory; for they are so packed with sericite and other alteration-products that extinction and index of refraction are usually undeterminable. The ground-mass is now a mixture of sericite, minute grains of feldspar, and mosaic quartz, the latter largely secondary. It was surely at one time in part glassy, but may have been in part felsitic. Apatite is an important accessory mineral.

Although the above represents the average alaskite-porphyry, several variations are to be noted. The rock forming the high hills on the Jesuit (1) and John F. (9) claims weathers more red than buff, and has a predominance of plagioclase, some of which is andesine. In connection with the origin of the biotite-granite, it is significant that the alaskite-porphyry, in several places, notably in the Emerald claim, contains microscopic biotite.

As all of the alaskite-porphyry is excessively silicified, it is possible that it originally contained, as an essential mineral, biotite, which has since been entirely replaced by quartz. A careful search for traces of this alteration, however, revealed few suggestions of such a change.

Along the contact of the alaskite-porphyry and the limestone are patches of what is known locally as quartzite—a name justified by the appearance of the rock; for it is to the naked eye a quartzite in every respect except that the presence of jointing

---

[6] *Mining and Scientific Press*, vol. xcix., No. 22, pp. 710 to 712 (Nov. 29, 1909).

suggests an intrusive. Microscopically, it is a mass of quartz grains with interstitial sericite, and undoubtedly represents an extreme silicification of the alaskite-porphyry, Figs. 10 and 11. This conclusion is based upon the study of many thin sections, which showed all stages from a partial replacement of the ground-mass by mosaic quartz, to a complete silicification with obliteration of all original structures of the alaskite-porphyry. The details of this silicification furnished some interesting petrography which cannot be discussed here. The difference between this "quartzite" and the quartz dikes will be discussed later.

Age.—The lack of good contacts between the alaskite and the alaskite-porphyry caused some difficulty in determining the relative age of these two rocks, a point of considerable economic importance. The alaskite-porphyry is considered to be younger, for the following reasons: (1) the exceedingly coarse alaskite shows no change in texture at the contact; (2) in the Hilda claim, the alaskite-porphyry seems to form a dike in the alaskite; (3) the contact dips under the alaskite; (4) it is most in accord with our knowledge of igneous rocks to have a large plutonic mass like the alaskite followed by a supplementary intrusion of smaller extent and porphyritic texture.

4. *Quartz Dikes.*

In the gulch in the Mollie claim there is in the alaskite-porphyry a dike 4 ft. wide with well-defined walls and showing the prismatic jointing characteristic of igneous rocks. The hand-specimen looks exactly like a light gray quartzite. Microscopically, it proves to be made up almost entirely of interlocking quartz grains, very dusty and full of inclusions, some of which suggest zircon by their shape, while others have the needle-like form of rutile, Fig. 12. A few flakes of sericite and some iron-decomposition products are present. Except for the abundance of inclusions in the quartz and for the well-defined field-relationships, there is nothing in this rock to distinguish it from the extreme phases of silicified alaskite-porphyry, and it is probable that other occurrences of this quartz dike have been passed over as silicified alaskite-porphyry. In the Mammoth mine such a dike has been traced in the five upper levels, but is not indicated on the map. This

rock is interesting as furnishing another instance of the gradation between fissures filled with quartz and acid intrusives.[7] It does not, however, show the feldspar phenocrysts found in similar rocks in the Yukon gold-district.[8] It is found only in the alaskite-porphyry, and is not much younger than that rock.

It might be urged that all the rock referred to above as silicified alaskite-porphyry is actually quartz dike. I believe, however, that the so-called "quartzites" of the district are in some cases dike-rocks and in others alterations of alaskite-porphyry. That some are dike-rocks is plain from the occurrence just described; that some are silicified porphyries seems equally plain from the transitions shown by thin sections, in which all stages have been traced, from partial replacement of the ground-mass by quartz to a complete silicification in which the former presence of feldspar phenocrysts is indicated only by the shape and kaolin-like inclusions of some of the quartz masses. While it is justifiable to believe that these quartzites are sometimes of one origin, sometimes of another, it is not always possible to class an isolated outcrop; and all have been mapped as a part of the alaskite-porphyry.

5. *Biotite-Granite.*

Under this heading are included a true granitic rock, and a porphyry which represents contact- and dike-facies of the same magma.

Distribution.—The biotite-granite proper forms two irregular masses on the claims of the Imperial Copper Co. (Fig. 1), while the porphyritic phase occurs as dikes in the limestone and the alaskite-porphyry. Many of these smaller masses are not shown on the map; but they are most abundant in the vicinity of the larger areas. Their peculiar shape will be discussed below. Biotite-granite is not as prominent on the Young America property as on that of the Imperial Copper Co.

This rock weathers to a buff color similar to that of the alaskite-porphyry, and when fine grained is to be distinguished from the latter only by the presence of biotite. Silicification may destroy this mineral; and then differentiation of the two

[7] Spurr, *Professional Paper No.* 55, *U. S. Geological Survey*, p. 129 (1906); and Lawson, *Bulletin*, Department Geology, University of California, vol. iii., No. 17, p 388 (1902–04).

[8] Spurr, *Trans.*, xxxiii, 310 (1903).

rocks is possible only by microscopic search for remnants of mica. In view of these conditions, the outlines of biotite-granite, as mapped, must be considered as expressing only approximate relations.

Description.—The biotite-granite forming the large masses is a holocrystalline rock of quartz, feldspar, and biotite, weathering readily to a buff friable rock, in which the hexagonal plates of greenish biotite are very prominent.

Only the porphyritic phases found as smaller masses and as dikes were compact enough for thin sections. These have a light gray to white ground-mass with large (0.5 cm.) phenocrysts of biotite and pinkish feldspar, and smaller crystals of white feldspar and quartz. The ground-mass, when not altered, is in some cases a close intergrowth of feldspar and quartz (0.005 mm.), while in other specimens traces of glass were found. The feldspar is more abundant than the quartz, and the relative amounts of orthoclase and plagioclase vary, the former usually predominating. The lime-soda feldspar is in the oligoclase-andesine series, and often weathers to epidote. The biotite was evidently titaniferous, for leucoxene is always among its alteration-products. Sphene and apatite are very important accessories; and some perofskite was noted.

Origin.—The magmatic relation of this biotite-granite to the other intrusions is of great importance in connection with the origin of the ores. In this connection, three points are significant: (1), the limitation of the rock to areas of alaskite-porphyry; (2), the mineralogical similarity between the alaskite-porphyry and the biotite-granite, especially as the former does, in some cases, contain black mica; and, (3), the peculiar shape and contact-relations of the biotite-granite. In regard to this, it should be said that the biotite-granite often occurs in the alaskite-porphyry as bunches, lenses, and irregular masses, which finger out into the wall-rock, and are mixed with it in a way not to be explained by ordinary intrusions along fissures. Although in some cases it shows signs of finer grain, due to chilling along the contact, small masses of it may be seen holding their holocrystalline texture throughout. Very irregular lenses are often found, that suggest inclusions caught up by the alaskite-porphyry rather than ordinary intrusions. In fact, when first seen in the field, the irregular masses of

granite were explained in this way; and this hypothesis was abandoned only when well-defined dikes of granite-porphyry were found in the alaskite. In view of the above facts, it is suggested that this rock represents a somewhat basic differentiation of the magma which supplied the alaskite and alaskite-porphyry, and that it was intruded shortly after the latter, which had not completely solidified. Where this biotite-bearing differentiation-product found the alaskite-porphyry still warm and pasty, it formed irregular tongues of biotite-granite; where the alaskite-porphyry had already solidified and fissured (on the contacts), it formed dikes of biotite-granite-porphyry.

The possible objection to the above theory is the well-known fact that in the splitting of a magma, the acidic intrusions more often follow than precede the basic.[9] On the other hand, it has been suggested that a differentiation of a rock-magma may take place through the crystallization and sinking of some of the mineral constituents.[10] Through this process biotite may have been concentrated in the depths of the parent magma of the Silverbell rocks; the upper (mica-free) portions being intruded or "tapped off" first, and the lower (biotitic) portions afterwards squeezed up by some later crustal movement. All discussion of magmatic differentiation is largely speculative; but the above theory explains so many features of the local geology, that it seems justifiable to consider Silverbell as a district where rock-differentiation by fractional crystallization is a very useful working-hypothesis.

6. *Quartz-Porphyry.*

Distribution.—This rock covers the entire eastern part of the area mapped, its boundaries being shown in Fig. 8. In general, it forms the higher hills to the east, and for this reason, and because of the large amount of glassy ground-mass, it may be taken for a surface-flow. If this is true, the portion remaining at the present day must represent the bottom of a very thick flow, for it is entirely free from gas-cavities. Moreover, its contact with the alaskite-porphyry, where exposed in the gulches, is vertical, and it has been found sending dikes into

---

[9] Spurr, Igneous Rocks as Related to Occurrence of Ores, *Trans.*, xxxiii., 288 to 340 (1903). See also Harker, *Natural History of Igneous Rocks*, chap. V.

[10] Harker, *loc. cit.*, and Iddings, *Igneous Rocks*, p. 251 *et seq.* (1909).

the limestone of the Silverbell (51) and Black Daisy (54) claims, and into the alaskite-porphyry of the gulch in Northern Star (15). I am inclined to regard it as an intrusive which came in considerably later than the alaskite series, after erosion had removed much of the overlying rock, so that it solidified under smaller pressure.

Description.—In the hand-specimen, the quartz-porphyry shows a dense black ground-mass, thickly studded with white feldspars about $\frac{1}{16}$ in. (rarely 0.25 in.) in diameter. It also contains angular black fragments, sometimes irregular in shape, at other times roughly rectangular, and bent as if by flowage. These probably represent fragments of glass from a first cooling, broken up by a partial remelting after the first solidification.

Weathering so bleaches the ground-mass that outcrops of the quartz-porphyry are light gray, offering less contrast in color to the alaskite-porphyry than one would expect from the appearance of fresh specimens. This gray is, however, distinctly different from the buff of the latter rock, and this, together with the presence of glassy fragments and many knots and veinlets of epidote in the quartz-porphyry, makes field-separation of weathered material comparatively easy—a much appreciated condition in this region of rocks of confusing similarity.

Under the microscope we see a true glassy ground-mass which owes its black color to an abundance of microlites and trichites. In this are scattered the phenocrysts of quartz, feldspar, and biotite. The extensive resorption of the first named is notable. The feldspars seldom show polysynthetic twinning, but in many cases have an index of refraction greater than balsam, so that much of the feldspar must be plagioclase, somewhere below oligoclase in the series. Foils of biotite varying in length from 0.1 to 1.0 mm. are common.

In view of the importance of the soda-lime feldspars as seen in thin sections, it is possible that this rock is more closely allied to the dacites than to the rhyolites. It is, however, possible that the glassy ground-mass represents a large amount of uncrystallized orthoclase; and for this reason, and because of the great abundance of quartz, I prefer to use the term quartz-porphyry, with the reservation that a chemical analysis might prove the rock to be a dacite. "Quartz-porphyry" is used instead of "rhyolite-porphyry" because the latter has been ap-

plied by mining-men to the alaskite-porphyry, and also because "quartz-porphyry" is a somewhat more elastic term.

This rock is little altered when compared with the alaskite intrusives, there being neither extensive silicification nor sericitization. The usual products of weathering by surface-waters are, of course, present, and the inclusions of glass are often changed to epidote. It is notable that the mica does not decompose to the leucoxene masses found in the biotite-granite, and is probably not titaniferous.

That the quartz-porphyry is definitely younger than the alaskite-porphyry, and that it has not undergone the extensive mineralization seen in the latter, are facts of considerable economic importance.

7. *Andesite.*

The most conspicuous dike-rock in this district is an andesite of later age than the ores, and of no economic importance. It occurs most frequently along a NW–SE. line from the Emerald- (49) Prospector (48) boundary to the railroad bend in the Pope (2) claim. In general, there seem to be three dikes, one varying from 15 to 30 ft., while the other two are only from 2 to 4 ft. in width. The largest is the "Birdseye" dike of the Mammoth mine. All dip from 80° to 85° to the SW. The most significant thing about these rocks is their irregular distribution. They are not the result of filling a straight and well-defined fissure, but form "corrugated dikes," showing great variation in width. They outcrop only occasionally at the surface and even then show as irregular patches, with greatly varying strike. The present topography is evidently at about the upper limit of the intrusion, for exposures in gulches show andesite bounded on the top and sides by alaskite-porphyry. It was only by locating all outcrops and by aid of the underground maps that their true relations were determined.

In appearance the andesite is a dark-gray, fine-grained rock, sometimes showing mica and feldspar phenocrysts. The microscope shows a mass of feldspar laths, largely oligoclase with occasional orthoclase, and flakes of biotite, sometimes bleached by weathering. Somewhat frequently quartz was found between the feldspar laths; but this rock is distinctly more basic than the quartz-porphyry.

None of this andesite was found in the quartz-porphyry and I am inclined to consider the latter as the older of the two.

8. *Miscellaneous Dikes.*

East of the quartz-porphyry, outside of the area mapped (Fig. 8), there is a complicated series of intrusive rocks and surface-flows entirely different from any rocks thus far described; and within the property of the Imperial Copper Co. were found some dikes which may be related to them, but which are locally unimportant, and will be mentioned only briefly.

Rhyolite-Porphyry.—This forms, in the eastern end of the Long Shot (52) claim, a 30-ft. dike which circles around to the north, just off the limits of the large map. It also occurs in the vicinity of the lead-silver prospects to the east (Fig. 8). It is more resistant than the quartz-porphyry in which it occurs, and stands out as a sharp wall from 10 to 20 ft. high. It has a dense pink ground-mass, with phenocrysts of quartz (2 mm.), orthoclase (3 to 4 mm.), and a few smaller biotites. The ground-mass is finely micro-crystalline, and zircon and magnetite are important accessories.

Hornblende-Andesite-Porphyry.—Small outcrops, not showing the whole thickness, were found in the Confidence claim, and much float of this material is present in the vicinity. The rock has a dark-green ground-mass, thickly studded with phenocrysts of plagioclase, in the labradoritic series. The ground-mass is a mixture of microscopic hornblende, a little biotite, and feldspar. The last is probably largely orthoclase, for it has an index of refraction less than balsam, and shows no polysynthetic twinning. In view of the uncertainty of the amounts of alkalic and calcic feldspars, classification is difficult; but the large amount of hornblende and the basic character of the abundant phenocrysts make it more closely allied to the andesites than the trachytes.

A tunnel in the John F. claim has exposed a similar dike, in which biotite largely replaces the hornblende.

IV. Age of the Rocks and Comparison with Other Localities.

It has already been noted that the limestone at Silverbell is probably Carboniferous, thus making the intrusive rock post-

Palæozoic in age. Prof. C. F. Tolman, Jr., has pointed out the general association of the copper-ores of southwestern Arizona with granitic rocks Mesozoic or younger in age.[11] Table I., which shows the kind and age of the post-Palæozoic intrusions of neighboring copper-districts, is therefore of interest. The names of rocks supposed to be genetically connected with the ores are italicized.

TABLE I.—*Post-Palæozoic Intrusives in Several Copper-Districts of Arizona and New Mexico.*

	Globe.	Bisbee.	Morenci.	Miami.	Ray.	New Mexico in General.
Tertiary.	Dacite.		Rhyolite, basalt and andesite lavas.			Rhyolite, basalt and andesite lavas.
	Schultze granite[a]		Diabase. *Granite- and Monzonite-porphyries.*	*Schultze granite*[a]	Dacite. *Granite.*	*Monzonites.*
Mesozoic.	Diabase. Monzonite.	*Granite-porphyry.*				

[a] Schultze granite is probably Tertiary, according to Weed and Tolman; *Mining and Scientific Press*, vol. xcix., p. 356, 1909. Ransome considers it probably Mesozoic; *Ibid.*, Feb. 12, 1910.

Exact determination of the age of an intrusive in any of the districts mentioned in this table may be uncertain, because the igneous rocks are not always in decipherable relations to sediments of known age. It is at once apparent, however, that the copper-ore deposits in Arizona and New Mexico are closely connected with a series of acidic intrusions which took place either at the close of the Mesozoic or at the beginning of the Tertiary, and that these acidic rocks were followed by less important intrusions of somewhat more basic character. This generalization applies very well to Silverbell, although in that district the greater part of the earlier intrusives is so free from dark silicates as to justify the name of alaskite, whereas the granites and monzonites of the other districts contain ferromagnesian minerals. This only strengthens the hypothesis advanced, that the normal magma from which these intrusions came was granitic, and that the alaskites are due to local dif-

[11] *Mining and Scientific Press*, vol. xcix., No. 11, pp. 356 to 358 (Sept. 11, 1909); No. 12, pp. 390 to 392 (Sept. 18, 1909).

ferentiation. It is also true that there is a great variation in the nature of the feldspars of these alaskites; the predominance of plagioclase in some specimens showing a transition to granodiorite. At Globe, Morenci, and Ray the granitic intrusions have been followed by more basic rocks—diabases or dacites, and the same general succession holds true for Silverbell, where andesite and a basic quartz-porphyry (dacite?) followed the alaskites. The complex series of later rocks occurring east of the area mapped will probably be found to correspond very closely to the Tertiary flows observed by Lindgren, Graton, and Gordon in New Mexico,[12] and by Lindgren at Morenci.

V. Alteration.

Under this head will be discussed all changes not definitely connected with contact-metamorphism or the actual deposition of ores, both of which will be treated in separate chapters. Apart from the disintegration of the granite, the effects of weathering are not extensive. The limestone and hornfels are coated with black "desert varnish," due to the deposition of manganese and iron oxides by the evaporation of vadose water;[13] joints of the igneous rock show dendritic coatings of secondary manganese oxide; and the usual alterations of feldspar to sericite, kaolinite, calcite, and occasional epidote, and of biotite to chlorite, are seen in thin sections. The buff and red staining of the outcrops of alaskite and granite is due to oxidation of disseminated pyrite.

More extensive and of greater interest is the alteration due to hot waters, probably of magmatic origin. This is of two kinds, sericitization and silicification; and its age and cause are fairly well established.

1. *Sericitization.*

Specimens of both granite-porphyry and alaskite-porphyry, even when taken from below the water-level, and apparently perfectly fresh, with bright pyrite cubes scattered through them, invariably show in thin section a ground-mass packed with sericite and quartz. The sericite also fills a large part of

[12] *Professional Paper No.* 68, *U. S. Geological Survey* (1910).

[13] Blake, W. P., *Trans.*, xxxv., 371 to 375 (1905).

the feldspar phenocrysts, often making the identification of the kind of plagioclase impossible. Microscopic veinlets of sericite are seen in nearly all sections (Fig. 13), and it is because these veinlets are often cut by quartz veinlets that the relative age of the two processes is known. Van Hise, quoting Lindgren, considers sericitization as the result of the action of carbonated waters upon feldspar. It may therefore be due to surface-waters; but if this had been the case at Silverbell, the andesites, quartz-porphyries and miscellaneous dikes should show similar effects. Although they do show some sericite—the result of surface-weathering—it is entirely distinct from the widespread sericite in the alaskite-porphyry and granite.

2. *Silicification.*

This is a striking feature of the alaskite-porphyry and granite-porphyry, and shows clearly in hand-specimens. In many places these rocks are cut by veinlets of quartz, or show lens-like inclusions of secondary quartz. In some instances quartz veins and lenses several feet in width are found, but masses an inch or less in diameter are more common. The alaskite-porphyry forming the hill-tops in the Jesuit, John F., Ruby, and Billy claims is much silicified, the replacement of the ground-mass and of the feldspars by quartz being clearly visible to the naked eye. In fact, the superior resistance of this siliceous rock seems to have been a factor in determining elevations. Microscopic examination of the alaskite-porphyry and the biotite-granite-porphyry shows that all of the rock has been attacked, to varying degrees, by siliceous waters. Making due allowance for the SiO_2 set free in the process of sericitization, it is evident that much quartz has been brought in. All stages have been observed, from that in which a few patches of mosaic quartz are found in the ground-mass to a complete change of the ground-mass to quartz, and a little sericite. In some cases the quartz still preserves traces of the feldspar form and structure. Often microscopic veinlets traverse the rock, and silicification has taken place from these. In some slides, veinlets of mosaic quartz were found cutting through original quartz phenocrysts; in others, the single crystals of quartz had been changed to a mosaic of small grains all differently oriented (Figs. 10 and 11).

As a rule, the silicification is strongest along the lime-contact, where it often produces "quartzite." As will be shown in the discussion of contact-metamorphism, silica-bearing waters evidently attacked the limestone itself. The existence of the quartzose cappings on the hills, mentioned above, is somewhat difficult to explain. It may be that the limestone was formerly more extensive, and that these hill-tops were once alaskite-porphyry, which formed a contact with limestone.

The quartz-porphyry and the later dikes are closely associated with the alaskite-porphyry and the granite, and there is nothing in their composition or structure to render them less susceptible to the action of mineralizing solutions; yet they do not show the changes just described. The sericitization and silicification, therefore, are attributed to magmatic waters rising along the granite and alaskite-porphyry shortly after their intrusion, and before that of the quartz-porphyry. That these waters did not migrate far from the rocks with which they were associated is shown by their slight effect on the coarse alaskite.

VI. Structures.

1. *Dip of the Limestone.*

Many attempts were made to determine the dip and strike of the limestone, but it is now altered to so massive a marble that former bedding-planes are not recognizable with any certainty. By considering the siliceous streaks and the hornfels as marking former beds, the general conclusion was reached that the strike varies from N–S. to NE–SW., while the dip is W. or NW., and nearly vertical. Careful observations taken at separate points, however, show such wide variation, and the discontinuous character of the hornfels beds is so noticeable in the underground workings, that we are forced to believe that great heat and pressure at one time changed the limestone to a mass of wax-like consistency, which the thrusts of successive intrusions molded and "kneaded" until the original structures were destroyed, and former beds were no longer continuous.

2. *Faulting.*

This district presents at first sight such an abundance of shearing-planes, shattered rock, and slickensided surfaces, that

important faulting is expected. A careful plotting of the dip and strike of these apparent lines of movement, both on the surface and underground, shows, however, that they have no uniformity, and seldom, if ever, connect to form well-defined lines of dislocation. They seem to be due to very small rock-movements, resulting either from the forces of the many intrusions, or from the readjustments attendant upon frequent heating and cooling. That there are true faults in the district is certain; but these involve such small movements, and the rock-contacts are themselves so irregular, that their detection is difficult. Time and again slip-planes were carefully traced in the mines until they met dikes or contact-lines, without finding any displacement. Moreover, the experience of the engineers has been that the ore-bodies have not been seriously disturbed by rock-movements. The faults that have been recognized fall into two classes, of different strike and age.

The earliest faulting took place after the intrusion of the andesite dikes, and followed them in strike and dip. It is recognized chiefly by the strong shearing and slickensides which are seen along the hanging-wall of the large dike in the Mammoth mine, where it is known as the "Mother Fault." Slickensides also appear on the wall of an andesite dike in a tunnel running from the Southern Beauty (24) to the Union (29) claim, and the andesite dikes often show sheared surfaces; but in no case has appreciable displacement been recognized.

Lines of NE–SW. faulting later than the above were found as shown on the map, Fig. 8. The most northerly of these faults was detected by tracing brecciated and slickensided rock to the lead-silver claims at the northeast of the district, where a rhyolite dike shows a horizontal displacement of about 150 feet.

Just east of the limits of the large map, in the gulch running down the Northern claim (30), the displacement of a rhyolite dike shows a fault, the rocks on the northern side having moved west about 50 ft. Faulting has not taken place along a single plane, but along many slickensided surfaces with considerable variation in strike, though the general line of movement has been NE–SW. What is probably the continuation of this fault is shown in the tunnel on the Southern Beauty (24) and Union (29) claims, where an andesite dike is displaced. The movement here, however, is not over 3 ft., indicating, appa-

rently, that this fault, which showed in one place a 50-ft. displacement, distributed its movement, farther on, among several widely-spaced planes. The similarity in shape of the two masses of biotite-granite in this vicinity suggests that one has been faulted down from the other, and a continuation of the above-mentioned fault-plane down the gulch in the Hilda claim (26) would fall in the right place for such a dislocation; but the small displacement shown by the dikes argues against this, and I am not inclined to believe that any such extensive vertical movement has taken place.

The third fault, shown in Fig. 8, on the Young America property, was detected by the presence of fault-breccia and a displacement of the contact between alaskite and alaskite-porphyry.

VII. Contact-Metamorphism.

The changes in texture and in mineral and chemical composition which have taken place at the contacts of intrusive rocks are not only theoretically important, but also closely connected with some of the ore-deposits; and an understanding of them is necessary before the genesis of the ores can be discussed. The contact-metamorphism is confined to the contacts of the limestone with the alaskite-porphyry and the biotite-granite-porphyry. It will be discussed under two heads: (1) the changes within the intrusives (endomorphism); and (2) the changes in the limestone (exomorphism).

1. *Endomorphism.*

It has long been noted that, except the textural differences due to quicker cooling, and occasional segregations on the margins, intrusives are seldom extensively changed at the contacts with wall-rocks, and this generalization holds true in the Silverbell district.

The most notable change, the silicification of the alaskite-porphyry and the biotite-granite-porphyry on the limestone contacts, is not an effect of the sediment, but is the result of siliceous waters rising from the depths of the magma and percolating slowly through the solidified margins of the intrusives.

It is reasonable to suppose that if assimilation of intruded sediments and consequent change in composition of the intrusive were a common occurrence, it would be well shown at

Silverbell, where the limestone was literally swamped in the igneous rocks, and the excess of molten material must have furnished more heat than is present when a sedimentary series is cut by igneous rocks of smaller extent. The fact is, however, that the contacts in this district very rarely show an increase in the lime-content of the intrusive.

In all cases, the boundary between limestone and alaskite- or granite-porphyry is sharp, and in a few instances only do the igneous rocks show an increase in lime-minerals. Of 20 or more thin sections of igneous rocks from the lime-contact, only one contained a few crystals of epidote, which, from their shape and included position in quartz, seemed to be pyrogenetic. One other slide showed hornblende, which might be attributed to the addition of enough calcium to the magma to cause the crystallization of an amphibole in place of the biotite.

In an open pit near the bend of the road in the Hamilton (35) claim there is a peculiar greenish-yellow rock at the contact of alaskite-porphyry and limestone. It is decomposed to a soft, clay-like mass, which defied determination in the hand-specimen; but a thin section showed that it is alaskite-porphyry now largely changed to diopside, which occurs in masses made up of club-shaped crystals from 0.1 to 0.05 mm. in diameter, with which are found occasional garnets. Another rock from the same pit appears to the naked eye like typical alaskite-porphyry, although somewhat silicified and copper-stained. Microscopically, it shows remnants of a felsitic ground-mass of quartz and feldspar, characteristic of alaskite-porphyry, but it is largely made up of an intergrowth of epidote and garnet, the existence of which was never suspected from the hand-specimen. The relationship of the diopside, garnet, and epidote to the rest of the rock in these two specimens is striking, for these minerals give every indication of replacing the original constituents (Fig. 14). The intrusive, therefore, does not appear to have fused into itself some of the limestone, thus forming a rich calcium magma from which epidote, garnet, and diopside crystallized. It seems rather as if the hot magmatic waters which circulated freely in this district after the intrusion were occasionally highly calcareous because of local leaching of limestone fragments, and were the cause of this

formation of lime silicates in the porphyry. It is believed that this calcium-content of these waters was due to leaching of limestone, and was not an original constituent of the magmatic solutions, because the formation of diopside, epidote, etc., in the porphyry is of limited extent and only a local effect, whereas the silicification and sericitization attributed to these same waters is wide-spread. In this respect, we find a difference from the Velardeña district, Mexico, where magmatic waters rich in calcium and silica changed a great part of the intrusive to a rock of garnet, epidote, and pyroxene much like the typical metamorphosed limestone.[14]

2. *Exomorphism.*

General.—The chief changes in the limestone seem to have been caused by the alaskite-porphyry and the biotite-granite. Little metamorphism is noticeable on the contact with the quartz-porphyry. In some parts of the district not studied in detail (Fig. 8), the limestone is in direct contact with coarse alaskite, and shows changes in no way different from those effected by the alaskite-porphyry or the biotite-granite. But because the extent and intensity of the alteration of the limestone varies directly with the amount of the last-named rocks present, they are believed to be the chief agents in the contact-metamorphism. The granite and the alaskite-porphyry seem to have produced exactly the same results; and no effort will be made to distinguish between effects of the two. The changes produced in the sediments by these two rocks are (1) recrystallization, (2) destruction of color, and (3) formation of irregular masses and bunches of garnet, with subordinate wollastonite, diopside, and other minerals.

Recrystallization.—This is extensive, none of the original clastic structures having been preserved; and although, in conformity with local usage, the terms "limestone" and "lime belt" have been used in this paper, there is no true limestone in the district; all calcareous material is now marble.

The dense siliceous rocks supposed to represent former clayey beds are also completely microcrystalline.

Loss of Color.—It is possible that the original limestones were black or nearly black, and that the white color of much

[14] Spurr and Garrey, *Economic Geology*, vol. iii., No. 8, pp. 688 to 725 (Dec., 1908).

of the marble is due to the driving off of carbonaceous coloring-matter. This view is supported by the finding of some blocks of black marble, which may represent fragments in which metamorphism has not gone very far. Moreover, some of the white marble is streaked with gray, and in some cases the gray predominates, forming a gradation to black marble banded with white. Exactly how much of the original rock was black and carbonaceous it is impossible to tell. A similar change in color has been noted in carboniferous limestone near Tucson.[15]

Formation of New Minerals.—At many places along the contact the limestone has been changed to great masses of garnet, with varying amounts of quartz, wollastonite, and diopside. This garnet rock is very resistant, and is stained black on the weathered surface by manganese, and thus forms the great black caps with which the ore is associated. Garnet in minor amounts may be found anywhere in the lime belt, but actual garnet rock occurs only along the contacts, and is best developed on the northwestern end of the largest "lime block," and in the outliers near by. Its distribution is shown on the large map, Fig. 1, but it always grades into the non-garnetized marble. It is noteworthy that the richest development of contact-metamorphic minerals (and also of ore) is near the largest amount of biotite-granite. Biotite-granite is less important in the Young America property, at the southeastern end of the lime belt, and contact-metamorphic minerals and ore are less abundant there than on the claims of the Imperial Co. Contact-metamorphism, however, is so irregular in this district that no definite conclusion can be based on this fact; but it does suggest that while the alaskite-porphyry was a metamorphosing agent, the granite was more important.

Going from the boundary of the intrusive rock into the sediment, we first pass a band, 3 to 10 ft. thick, of solid garnet and quartz, with varying amounts of wollastonite, and microscopic diopside. This is gradually replaced by garnet rock with veins and bunches of marble, and the latter becomes more abundant until we find marble with lenses and stringers of garnet and associated minerals, and these become less numer-

[15] Blake, W. P., Report of Governor of Arizona for year ended June 30, 1904, p. 72.

ous until a pure marble remains. There are so many dikes in this district, and the contacts are so irregular, that it is impossible to say how far from the intrusive mineralization has extended, but 500 ft. is probably the maximum. The relation of the garnet to the marble is remarkable. It apparently follows no former bedding-planes or lines of fissuring, but forms stringers, short veins, and lenses, strongly suggesting the occurrence of pegmatite masses in some gneisses. An open pit northwest of the Mammoth shaft in the Hamilton claim (35) gives a good section of the solid garnet rock on the contact. Here two types can be recognized: a wollastonite rock, composed largely of dense white wollastonite with subordinate garnet, and a garnet-quartz rock in which rich brown garnet and colorless quartz are intermingled in masses of varying size. The second rock cuts through and includes fragments of the first.

The garnet rock shows microscopically the same characters whether taken from solid masses on the contact or from lenses farther away from the intrusive. There is considerable variation in the relative amounts of the minerals, but otherwise the following description will apply to the typical garnetized marble. The rock is an intricate mixture of garnet, quartz, wollastonite, diopside, and calcite. Wollastonite is invariably the first mineral formed, and diopside (which is comparatively rare) is next in age (Fig. 15). The quartz and garnet are intergrown in a puzzling way, apparently having been formed at about the same time. Some rocks show a ground-mass of finely crystalline calcite, which may represent the residue of the original limestone; but a careful search through many sections failed to reveal any definite evidences of garnet replacing original calcite. All the rock-specimens show veinlets of quartz and calcite later than the previously-mentioned minerals. In many slides it seemed as if garnet had formed with its own crystal boundaries, leaving cavities into which quartz and calcite solutions had afterwards filtered. (Figs. 16 and 17.)

The lack of epidote is remarkable, for in other districts it very often accompanies garnet as a contact-metamorphic mineral. It has been found in a few places, close to the contact, but is usually rare in the altered limestone. Some lenses of quartz were seen in the marble, surrounded by reaction-rims of

wollastonite, similar to those described by Professor Crosby.[16] The contact-metamorphic minerals in this district are comparatively few, those recognized being garnet, quartz, wollastonite, diopside, epidote, scapolite (?), and plagioclase. It is to be noted that minerals with fluorine, boron, and other so-called "mineralizers" are practically absent—which coincides with the description of most other contact-metamorphic ores.

The Origin of the New Minerals.—In a study of contact-metamorphism four problems always arise, viz.: (1) What, if any, substances did the intrusive add to the sediment; (2) what changes in volume have taken place; (3) what determined the loci of metamorphism; and (4), how were the new minerals formed? The most suggestive discussions of these questions have come from Professors Kemp, Barrell, Vogt, Stutzer, and Leith, and Messrs. Lindgren and Weed. References to important papers will be found in the appended bibliography.

Addition of Material.—In determining whether contact-metamorphic minerals are the result of recrystallization of impurities originally present in the limestone, or of substances added by waters given off by the intrusive, a knowledge of the composition of the unaltered limestone is essential. In the Silverbell district the destruction of all bedding makes it impossible to follow a definite garnetized layer into its unaltered equivalent. Moreover, there is no absolutely unmetamorphosed limestone in the area studied. In the marble farthest away from the contact there are lenses and stringers of more siliceous material, the shape and position of which so correspond to the lenses of garnet, that it might be thought that recrystallization of similar masses of impure limestone gave rise to the characteristic minerals of the garnetized belt. An analysis of one of these lenses of impure marble gave the following:

SiO_2	17.46
Al_2O_3 } Fe_2O_3	1.75
CaO	45.76
MgO	2.26
Ignition-loss,	33.31
	100.54

[16] Crosby, W. O., Limestone-Granite Contact-Deposits of Washington Camp, Arizona, *Trans.*, xxxvi., 626 to 646 (1906).

This rock is crystalline, although much finer-grained than the average marble; and that it contains some wollastonite is shown by the microscope, and by recalculation, considering the loss on ignition as CO_2, so that it does not represent unaltered sediment. It is notable that the chief impurity is SiO_2, and that Fe_2O_3 and Al_2O_3 are very low. An analysis of the purest and freshest garnet obtainable gave the following:

SiO_2	36.85
Al_2O_3	9.62
Fe_2O_3	17.54
FeO	1.62
MgO	1.11
CaO	31.87
MnO	0.51
H_2O—110°	0.27
	99.39

Some CO_2 was present, but was not determined. A recalculation shows that the garnet is a mixture of the following species in the proportions given:

Andradite,	53.4
Grossularite,	37.4
Pyrope,	4.4
Almandine,	3.5
Spessartite,	1.2

A little silica and calcium are left, which are accounted for by the quartz and calcite found in thin section.

This agrees with the work of Professor Kemp and Mr. Lindgren, who have shown that the contact-metamorphic garnets are usually predominantly of the lime-iron variety. In view of the fact that the most impure lime rock in this district contains such insignificant amounts of iron and aluminum, the inevitable conclusion is that here, as in so many other districts, the garnet has been formed by reaction between the calcium of the original sediment, and silica, iron, and alumina brought in by hot waters given off by the intrusive. This idea is confirmed by finding with the garnet the great masses of quartz, which in size and field-relationships show no sign of being metamorphosed sediments. It is possible, on the other hand, that the wollastonite is, in part, at least, the result of the recrystallization of siliceous portions of the limestone. This

view is strengthened by the observed reaction-rims between marble and flint nodules. Both Professor Barrell and Mr. Weed have shown that wollastonite is often formed by recrystallization, even in districts where additions from the intrusive characterize the contact-metamorphism. In such cases the wollastonite formation takes place first, and the resulting porosity makes room for the entrance of solutions from the magma. The fact that at Silverbell the wollastonite is the first formed of the contact-minerals suggests that a similar sequence of events has taken place there.

It is not necessary to assume addition of material to account for the minerals in the hornfels; they may be due to a recrystallization of a siliceous shale.

Volume-Changes.—When an impure limestone is recrystallized to a mass of contact-metamorphic minerals, a notable shrinkage in volume must take place. Into the pores thus formed may come magmatic waters bearing silicate solutions and ores.[17] Recrystallization, however, has not played an important part at Silverbell, yet there is evidence of the formation of considerable open space. Microscopically, the garnet often shows crystal boundaries, and a characteristic of many thin sections is garnet with cavities and veinlets filled with calcite and quartz. Small vugs lined with garnet are sometimes seen with the naked eye, although, as a rule, the garnet rock appears very dense, because all cavities have been filled by later minerals. Moreover, the ores are distinctly later than the garnet, in which they occur as veinlets or as disseminations. In accounting for the formation of these cavities we must take into consideration the following facts. The formation of andradite by the addition to a limestone of iron and silica, and the removal of CO_2, means an increase in volume. If the original limestone had a porosity of 10 per cent. and the resulting andradite were practically non-porous, the total increase would be roughly 20 per cent. On the other hand, the change from a porous limestone to a dense marble involves a shrinkage, probably of 10 per cent. in the case of a limestone of average porosity. Now, the greater part of the limestone at Silverbell has been recrystallized to marble, and only a minor amount, even near the contact, has been changed to garnet.

[17] Weed, *Trans.*, xxxiii., 715 to 746 (1903).

If we assume that one part of limestone has been garnetized with an increase of 20 per cent. in volume, and nine parts have been marmorized with a decrease of 10 per cent., the net shrinkage resulting from the two processes will be 7 per cent. of the original volume. The fact that this shrinkage caused porosity in the garnet rock, and not in the marble, may be accounted for by magmatic waters under great pressure being abundant near the contact and thus keeping the pores open.[18] These waters may also have dissolved out considerable calcite and redeposited it away from the contact. The well-defined veinlets may be due to contraction on cooling. Whatever may be the cause, the fact remains that the garnet rock at Silverbell was characterized by microscopic pores as well as by well-defined minute fissures, which were afterwards filled by other minerals. It does not seem probable, however, that these open spaces were extensive enough to account for all of the ore-deposition, some of which was very likely due to replacement of calcite and garnet.

Locus of Metamorphism.—Since, in this district, contact-metamorphism and ore-deposition have gone hand in hand, the determination of the factors causing metamorphism in some parts of the limestone and not in others would be of great practical value. In other regions, the following reasons have been assigned for the irregular distribution of the contact-effects. (References will be found in the bibliography.) The more ready access afforded the solutions by bedding-planes or fracturing of the sediments is supposed to have been a determining factor at Bingham, Cochise, and Taylor Peak. At Marysville, Mont., and Sonora, Mexico, the porosity resulting from recrystallization of impure limestone has determined the place of entrance of magmatic waters, while at Washington Camp, Ariz., metamorphism is limited to impure beds, although here no addition of silicates from the intrusive is considered probable. At Morenci the purity and porosity of the limestone were the favorable conditions for contact-metamorphism, while local irregularities were accounted for by variations in the water-content of the intrusive. At Silverbell there is the possibility that the changing of patches of siliceous limestone to

[18] In regard to cavity-formation by water under pressure, see L. C. Graton, *Bulletin No.* 293, *U. S. Geological Survey*, pp. 59 to 60 (1906).

wollastonite formed porous rock, which admitted the magmatic emanations more readily; but in view of the subordinate importance of the wollastonite this is not probable. The two more effective factors were fissuring in the limestone and local variation in the amounts of water given off by the intrusive. It is not to be understood that contact-metamorphism along well-defined fissure-planes has been recognized. The complete "stewing up" of the limestone prevents this; and it is simply suggested that lines of fissuring in the original rock allowed the magmatic emanations their first entrance. The complete obliteration of all original structures prevents any conclusion of practical importance.

Method of Precipitation.—It has long been asserted as a matter of course that contact-metamorphic minerals were formed by siliceous solutions from the intrusive, reacting with the calcite of the limestone, and replacing it metasomatically, molecule by molecule. Professor Stutzer [19] has suggested that it is possible for the magmatic waters to dissolve the calcite, thus forming a solution consisting of the iron, silica, etc., from the intrusive plus the lime from the sediment; that this solution may eat its way into the limestone until saturation and cooling cause it to precipitate contact-metamorphic minerals, much as minerals are precipitated in pegmatite veins. This is a somewhat conjectural question; yet I cannot but think that the lack of microscopic evidence of replacement, the sharp boundaries of the garnet stringers and lenses, and their peculiar field-relations, suggesting "eating into" the marble, are best explained, not as the result of molecular replacement, but as precipitation from highly-heated solutions, which worked their way into the sediment under great pressure, much as pegmatitic stringers have formed in the injection-gneisses. Under this hypothesis, the small pores in the garnet rock would be similar to miarolitic cavities in pegmatites.

VIII. Ore-Deposits.

The ore-deposits of the Silverbell district are of three kinds: contact-metamorphic deposits of copper; copper-ore disseminated in igneous rocks; and lead-silver veins.

---

[19] Stutzer, O., Kontaktmetamorphe Erzlagerstätten. Zusammenstellungen und Betrachtungen. *Zeitschrift für praktische Geologie*, vol. xvii., pp. 145 to 155 (Apr., 1909).

1. *Contact-Metamorphic Copper-Ores.*

General.—The ores of this class, which have furnished practically all the product of this district, have been worked in three mines, all owned by the Imperial Copper Co.: the Mammoth, the Union, and the Billy; the last two being close together and connected underground. The Mammoth has furnished the richest ore, although its deposits were even more irregular than those of the Union. When last worked, the Mammoth was producing sulphide ore, the Union both sulphide and oxidized ore, but chiefly the latter; while the Billy has been of value as a source of lean cupriferous pyrite, to mix with the oxide ores of the Union. By judicious combining of the products of the three mines a self-smelting ore was obtained, so that in two years' run the Sasco smelter used no flux. The sulphide ore may run as low as 2.5 per cent. of copper, although many masses showing 10 or 15 per cent. have been found. One 6-ft. breast of nearly solid chalcopyrite was worked out in the Mammoth. The oxide ores carry from 8 to 12 per cent. of copper on the average, while the lean pyrite ores of the Union may have less than 1 per cent. Except some isolated pockets, all the ore is low in silver, averaging not more than an ounce to the ton. It was in the oxidized portion of these separate pockets of lead-silver ore that the first work in the district was done, the assays often showing from 15 to 17 oz. of silver. The notion that these deposits as a whole are valuable for both copper and silver, and that the oxidized ores are characteristically rich in silver, is incorrect.

Shape and Distribution.—The ore-bodies are very irregular, the smaller ones forming pockets and bunches, often roughly lenticular in shape. The larger deposits are more like pipes or chimneys several hundred feet in vertical dimensions and pinching and swelling in diameter from 20 to 100 ft. or more. Horses of more or less garnetized marble are often seen. Tongues, stringers, and other off-shoots of ore into the marble wall-rock are common.

In general, the ore is found on the contact of the marble with either alaskite-porphyry or biotite-granite-porphyry. Parts of an ore-body may be 100 ft. or more from an intrusive rock; but some portion of every ore-mass is close to the contact with

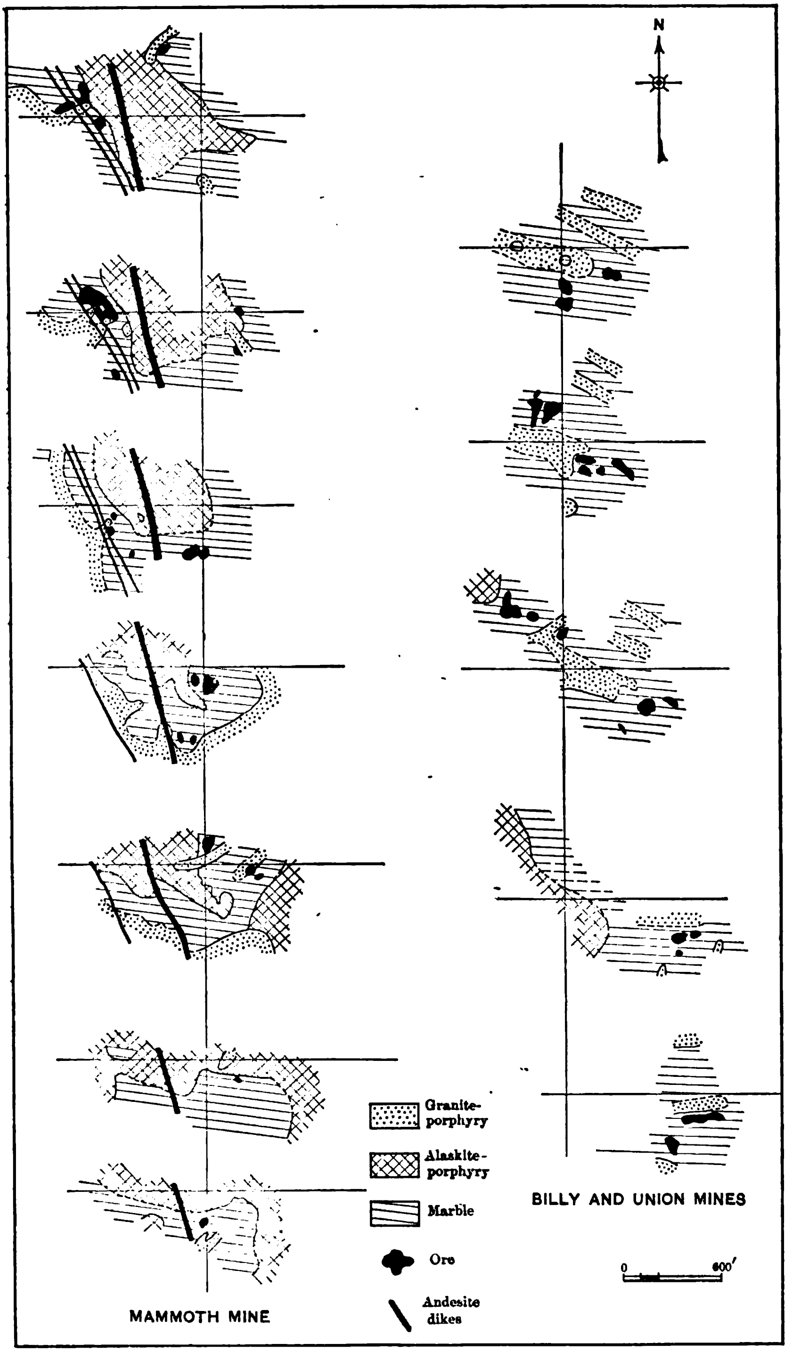


FIG. 18.—GENERALIZED HORIZONTAL SECTIONS ON THE LEVELS OF THE MINES OF THE IMPERIAL COPPER CO. THE VERTICAL AND HORIZONTAL LINES MARK THE INTERSECTION OF VERTICAL PLANES, SO THAT CORRESPONDING POINTS MAY BE EASILY FOUND. LEVELS ARE AT APPROXIMATELY 100-FT. INTERVALS.

one of the two above-named igneous rocks. Usually there is a 5- to 10-ft. band of garnet rock between ore and porphyry. The relation of the metalliferous deposits to the biotite-granite-porphyry and the alaskite-porphyry can best be understood by references to the sketches of the underground geology in Fig. 18. These maps are based on work done by me, except those of the three upper levels of the Mammoth mine, which were made by the engineers of the Imperial Copper Co. The black patches indicating ore do not differentiate between ore worked out and ore in sight, nor do they show all of the ore-bodies or their actual size. They do serve, however, to give an accurate idea of the shape and distribution of these bodies. Several interesting facts brought out by these maps are referred to under the discussion of the origin of the ores.

Contact-metamorphic copper-ores are found in other places in this district, but the only ones that have been extensively developed are those on the property of the Imperial Copper Co. described above. The Young America has a 500-ft. shaft on the contact; and while the price of copper was high this was leased and worked at considerable profit, but in later years the company has confined its operations to prospecting the disseminated ores in porphyry. In the NW. end of the lime belt, copper-stains have been found in the garnet caps, but what exploration has been done has failed to reveal any considerable amount of ore. The El Tiro shaft (Fig. 8) got most of its output from ore in the alaskite. The contact-metamorphic ores, therefore, are most important where biotite-granite is well developed.

Ore- and Gangue-Minerals.—The unaltered ore-bodies consist chiefly of cupriferous pyrite and chalcopyrite, with small and irregular amounts of sphalerite and galena, in a gangue of garnet, quartz, calcite, and wollastonite. The oxidized ores are a somewhat friable mixture of earthy red hematite, copper oxide (probably cuprite), and clayey decomposition-products of the gangue-minerals. Other minerals found in minor amounts are given below.

Bornite, rare and probably secondary.

Chalcocite, rare.

Native copper, found in some oxidized ores, but not important.

Azurite, malachite, and chrysocolla, fine specimens are said to have been found in the early days of the camp, and stains are now seen.

Molybdenite, in small stringers and one large pocket in the sulphide ores.

Siderite, a few small crystals found.

Magnetite, reported from one place in the Mammoth, but both it and specularite practically lacking here.

Barite, platy masses in stringers, but not generally mixed through the ores.

Fluorite, green in color, was found in considerable quantity in an old lead-silver pit near the Mammoth, but in alaskite-porphyry and not in the contact-ores.

Wulfenite, brownish plates in same body as the fluorite.

Cerussite in silky crystals, hershelite, and earthy mixtures of lead and zinc carbonates in some parts of the oxidized ores.

The ore-minerals are definitely later than most of the gangue-minerals, and occur commonly as veinlets in the garnet-quartz-calcite-mass, or disseminated through it. The formation of quartz seems to have extended over a considerable period, beginning with the crystallization of garnet and lasting until after the precipitation of the ore-minerals. There has been some post-ore deposition of calcite. These facts coincide with the paragenesis of contact-ores in general.[20] A few polished specimens studied in reflected light showed that while pyrite and chalcopyrite are often intergrown with sphalerite, neither of them is found in the galena observed in the same specimens; moreover, this galena seems to be younger than the sphalerite. The significance of this fact is discussed in connection with the origin of the lead-silver ores.

Secondary Enrichment.—The oxidized zone in the contact-ores is, in general, about 250 ft. deep, but its lower limit is rather irregular, being influenced by the lines of fracture and shearing that are so abundant, The ore in this zone is considerably enriched by the leaching-out of the sulphur and some of the iron- and gangue-minerals. A sulphide ore carrying from 2 to 3

---

[20] *Engineering and Mining Journal*, vol. xc., No. 11, pp. 513 to 515 (Sept. 10, 1910).

per cent. of copper will show 10 or 12 per cent. in the oxidized zone. This process of leaching has not affected the copper. There is little migration and secondary precipitation of this metal in the ores, and oxide bodies pass to original sulphides with no transition-zone of secondary sulphides. This fact, taken in connection with the formation of secondary chalcocite in the porphyry-ores of this same district, is a further confirmation of the idea advanced by D. C. Bard that calcitic gangue has a tendency to prevent the downward migration of copper.[21] The results of some experiments along this line by T. B. Welch and myself are now in preparation, and show that calcite does have a precipitating effect on copper sulphate. A puzzling feature of the Silverbell ores, however, is the small amount of carbonate in the oxidized zone. Possibly the larger amounts of manganese present may account for the excess of copper oxides, but experiments to test this hypothesis have thus far given no satisfactory results.

2. *Disseminated Copper-Ores.*

Pyrite, more or less copper-bearing, is common throughout the fresh alaskite-porphyry, the alaskite, and the granite, and its weathering-products have stained these rocks red or buff at the surface. Occasionally, green copper-stains are seen, but usually the copper has gone into solution and been precipitated below. Extensive prospecting has been done, first by test-shafts and later by churn-drilling, in an effort to discover a workable deposit of disseminated copper-ore in these rocks. The results of these operations were not available as far as definite figures go, but some facts of importance in regard to the geology were obtained.

These disseminated ores can be of value only where secondary enrichment has taken place. Chalcocite of secondary character can be found anywhere in the camp, but not always sufficiently rich or extensive to make a workable deposit. Prospecting in the alaskite-porphyry, although showing some rich streaks, was unsatisfactory; and the Imperial Co. has turned its attention to the coarse alaskite, with much better results. One of the best holes showed 60 ft. of 2-per cent. ore. A microscopic examination of some specimens shows that the

---

[21] *Economic Geology*, vol. v., No. 1, p. 59 (Jan., 1910).

ore occurs as minute stringers and specks of chalcocite in the alaskite. It usually has a core of unaltered pyrite, and the pannings from the drill-samples show pyrite cubes, coated with chalcocite, and some pseudomorphs of chalcocite after pyrite.

The depth to which the oxidized zone extends is extremely variable, but generally not more than 100 ft., and the zone of secondary sulphides is from 50 to 60 ft. thick. Some holes have gone through a chalcocite zone, into an oxidized zone, and then back to chalcocite; and it is very common to pass through bright fresh pyrite before reaching the chalcocite. Ore shipped from the El Tiro shaft was from a zone of much broken alaskite and consisted of chalcocite, coating stringers of pyrite. Here oxidation had extended to the unusual depth of more than 300 ft., and secondary sulphides were found down to the 500-ft. level. A cave-in stopped mining-operations before much was known of the geology. The El Tiro ore was concentrated, and the tables are said to have shown a mixture of chalcocite with cuprite and native copper.

The alaskite probably shows richer concentrations of chalcocite than the porphyry, not because of higher original copper-content, but because its coarseness of grain and numerous joints have been more favorable to the processes of secondary enrichment. The varying depths of the chalcocite zones, the alternation with oxidized material, and the presence of pyrite above some of the chalcocite, are believed to indicate that this secondary concentration has been made extremely irregular by the influence of sheared and fissured areas. This seems to be confirmed by the occurrence at the El Tiro. If it be true, mining these disseminated ores will be an unusually difficult matter, and very careful exploration will be necessary to allow for the sudden changes which will be found in the boundaries of the chalcocite zone.

All the drilling in the Young America property has been confined to the alaskite-porphyry, but whether with more favorable results than the Imperial Co. obtained in the same rock, is unknown.

3. *Origin of the Copper-Ores.*

That contact-metamorphic ores are the result of magmatic emanations from the accompanying intrusive is too generally

accepted to need further discussion here. The question of importance at Silverbell is, which igneous rock caused the ore-deposition?

In the early days of the camp no distinction was made between alaskite-porphyry and granite-porphyry, and prospecting was done indiscriminately along the contact of the marble with either of these two rocks. When the types were distinguished, the alaskite-porphyry was considered as the source of the mineralization; but B. L. Smith, the present superintendent, was struck by the fact that granite-porphyry was often the igneous rock nearest the ore. A reference to the maps in Fig. 18 will show that except for some lean pyrite bodies on the west that are in the Billy mine, all the ores of the Union are associated with granite-porphyry, occurring most often near the end of a large tongue of this rock. In the Mammoth mine alaskite-porphyry is the chief rock on the north of the marble, and granite-porphyry on the south and west, and ore-bodies are found on both contacts. The north, however, is not exclusively alaskite-porphyry, but shows tongues of granite-porphyry, and usually any ore-body, if followed vertically from one level to another, will somewhere come in close contact with a mass of granite-porphyry. When we consider, in addition, the greater amount of contact-metamorphism and ore-deposition apparent in that part of the district where biotite-granite is best developed, we cannot escape the conclusion that it was the most important source of mineralizing solutions. That it was not the only source is shown by the lean pyrite bodies in the Billy, where alaskite-porphyry is the only intrusive.

The magmatic solutions that caused the contact-metamorphism and the ore-deposits probably were not given off exclusively by the igneous rocks now seen. It is believed that these emanations came from the depths of the magma and rose along the intrusive. This seems most in accord with the alteration undergone by the alaskite- and granite-porphyries, and with the fact that the pyrite of the igneous rocks is a later impregnation and not pyrogenetic. The origin of the copper-ores, therefore, was most probably as follows: Beginning with, and continuing after, the intrusion of the alaskite-porphyry, hot waters rose along this rock from the magma below. These waters were first rich in CO_2, then siliceous and ore-bearing;

they first sericitized the igneous rocks, then silicified them, at the same time metamorphosing the limestone to garnet rock; and, lastly, they impregnated the porphyry with cupriferous pyrite, and deposited pyrite and chalcopyrite in the contact-zone, both by filling minute pores and fissures and by replacement. Before the alaskite-porphyry was completely solidified, and while these emanations were still being given off, biotite-granite was intruded from the parent magma, thus opening up channels along which the emission of the above-mentioned hot waters took place with renewed activity. It is, therefore, logical to expect to find contact-ores near the alaskite-porphyry, but a more favorable place, and one where the ores may be considerably richer, is where tongues of granite-porphyry are present.

The above explains the origin of the cupriferous pyrite in the alaskite-porphyry and granite as a deposition from solutions coming up from below, but it does not account for the pyrite in the coarse alaskite which has furnished the favorable chalcocite-prospects. For this two views are possible: (1) the solutions from the porphyry may have penetrated the alaskite and thus impregnated it with pyrite; or (2) ore-bearing solutions may have come up along the coarse alaskite shortly after its intrusion, and entirely independent of the porphyry. If the first view is correct, the chalcocite-deposits may be expected to extend not far from the contact with the porphyry. Thus far, all prospecting has been done near the contact, and the possibility of this limitation in extent may well be kept in mind.

In view of the fact that the coarse alaskite does not show much of the silicification characteristic of the action of the waters rising along the porphyry and granite, it may well be that these emanations did not affect this rock. In that event the coarse alaskite would owe its mineralization to hot solutions arising from below shortly after its intrusion, and entirely independent of the porphyry, and its chalcocite-deposits would not be limited to the contact. As this rock is doubtless derived from the same general magma, there is no apparent reason why its intrusion should not have been followed by ore-bearing solutions similar to those associated with the porphyry.

4. *Lead-Silver Ores.*

As has been noted above, several pockets of lead-silver ore were worked in the vicinity of the Mammoth mine in the early history of the district. At the present time the small amount of silver found in the copper-mines of the Imperial Co. is in distinctly separate stringers and bunches.

East of the property of this company residents of Silverbell have taken up a number of claims on a fissure-vein of lead-silver ore in the quartz-porphyry (Fig. 8). In this vicinity are dikes of rhyolite-porphyry, and a more basic rock called mica-andesite by Prof. C. F. Tolman, Jr. The vein is the filling of a fault-fissure that strikes nearly N–S., dips 80° W., and has been followed more than 500 ft. along the strike, with one spur running a short distance to the east. This is undoubtedly a distinct fault-fissure; for it cuts off a rhyolite dike, and is filled with brecciated material. Some post-mineral movement has taken place along the western wall. A shaft about 100 ft. deep, sunk on the vein, shows that the deposit is really a cementing of a brecciated zone which is about 5 ft. wide at this point. The ore is galena in a gangue of fluorite, calcite, quartz, and fragments of quartz-porphyry. Considerable cerussite and anglesite occur in the upper part, and native silver and cerargyrite are said to have been found by the prospectors. There are a few green stains of copper carbonate, but the outcrop of the vein is for the most part not marked by discoloration. The owners of the claims report very favorable assays, and are planning active exploration.

A thin section of one of the wall-rock fragments found in the vein shows a quartz-porphyry now much altered. Only a few patches of the original ground-mass remain, the rest being a mass of fine-grained quartz and some larger fluorite crystals. The mica and the feldspars have largely disappeared also, but the quartz phenocrysts and unaltered ground-mass bear a close resemblance to the fresh quartz-porphyry. Having in mind the fact that the copper-ores of Silverbell were first worked for silver, several engineers have expressed the opinion that this ore-body also would probably turn to copper in depth. This is reasoning on a false analogy, for this lead-silver vein is in the quartz-porphyry, and therefore is later

than the contact copper-ores, and due to an entirely distinct period of mineralization.

In this connection it is interesting to consider the origin of the occasional silver-ores found in the contact copper-deposits. None of these was being worked when I visited the district, but Mr. Smith was emphatic in saying that high silver-values are sharply localized. It is possible that the same mineralization which caused the vein just described also formed the stringers of lead-silver in the contact-deposits. I could not get sufficient data on the shape and mineral content of the ores in question to justify a definite conclusion, but the above suggestion is supported by the finding, in an old lead-silver working near the Mammoth shaft, of great quantities of fluorite, which is unknown in the contact-ores proper, and by the evidence of polished specimens, that, while sphalerite is clearly associated with the copper-minerals, galena is not.

In any event, there can be no doubt that there is no apparent reason to expect the lead-silver prospects on the east to change to copper-ore in depth.

IX. Bibliography.

1. *References to the Geology of Arizona.*

Barney, W. G., The Silverbell Mountains, Arizona, *Engineering and Mining Journal*, vol. lxxviii., No. 19, pp. 755 to 756 (Nov. 10, 1904).

Blake, W. P., The Geology of Arizona, Report of the Governor of Arizona for year ending June 30, 1904, pp. 66 to 72.

Comstock, T. B., Geology and Vein-Phenomena of Arizona, *Trans.*, xxx., 1038 to 1101 (1900).

Lindgren, Waldemar, The Copper Deposits of the Clifton-Morenci District, Arizona, *Professional Paper No.* 43, *U. S. Geological Survey* (1905).

Lindgren, W., L. C. Graton and C. H. Gordon, Ore Deposits of New Mexico, *Professional Paper No.* 68, *U. S. Geological Survey* (1910).

Ransome, F. L., Geology of the Globe Copper District, Arizona, *Professional Paper No.* 12, *U. S. Geological Survey* (1903).

——— Geology and Ore Deposits of the Bisbee Quadrangle, Arizona, *Professional Paper No.* 21, *U. S. Geological Survey* (1904).

Tolman, C. F., Jr., Disseminated Chalcocite Deposits at Ray, Arizona, *Mining and Scientific Press*, vol. xcix., No. 19, pp. 622 to 624 (Nov. 6, 1909).

——— Copper Deposits of Silverbell, Arizona, *Mining and Scientific Press*, vol. xcix., No. 22, pp. 710 to 712 (Nov. 27, 1909).

——— The Miami-Inspiration Ore-Zone, *Mining and Scientific Press*, vol. xcix., No. 20, pp. 646 to 648 (Nov. 13, 1909).

——— Southern Arizona Copper Fields, *Mining and Scientific Press*, vol. xcix., No. 11, pp. 356 to 360 (Sept. 11, 1909); No. 12, pp. 390 to 393 (Sept. 18, 1909).

Wheeler, G. M., *Geographical and Geological Surveys West of the One Hundredth Meridian.* Final Report, vol. iii (1875).

Weed, W. H., The Ray Copper Mining District, Arizona, *Mining World*, vol. xxxiv., No. 2, pp. 53 to 56 (Jan. 14, 1911).

2. *Special Papers on Contact-Metamorphism.*

Barrell, Joseph, Physical Effects of Contact Metamorphism, *American Journal of Science*, ser. 4, vol. 13, No. 76, p. 279 (Apr., 1902).

Beck, Weed, *The Nature of Ore Deposits*, pp. 582 to 606 (1905).

Beyschlag, F., P. Krusch and J. H. L. Vogt, *Der Lagerstätten der Nutzbaren Mineralen und Gesteine*, pp. 344 to 370 (Stuttgart, 1910).

Blake, W. P., Copper-Ore and Garnet in Association, *Trans.*, xxxiv., 886 to 890 (1904).

Kemp, J. F., Ore Deposits at the Contacts of Intrusive Rocks and Limestones, and Their Significance as Regards the General Formation of Veins, *Economic Geology*, vol. ii., No. 1, pp. 1 to 13 (Jan.–Feb., 1907).

Keyes, C. R., Garnet Contact Deposits of Copper and the Depths at which They Are Formed, *Economic Geology*, vol. iv., No. 4, pp. 365 to 372 (June–July, 1909).

Klockmann, F., Uber Kontaktmetamorphe Magnetitlagerstätten, ihre Bildung und systematische Stellung, *Zeitschrift für praktische Geologie*, vol. xii., pp. 73 to 85 (Mar., 1904).

Lindgren, W., Character and Genesis of Certain Contact-Deposits, *Trans.*, xxxi., 226 to 244 (1901).

Stutzer, O., Kontaktmetamorphe Erzlagerstätten. Zusammenstellungen und Betrachtungen, *Zeitschrift für praktische Geologie*, vol. xvii., pp. 145 to 155 (Apr., 1909).

Van Hise, C. R., A Treatise on Metamorphism, *Monograph XLVII., U. S. Geological Survey* (1904).

Vogt, J. H. L., Problems in the Geology of Ore-Deposits, *Trans.*, xxxi., 125 to 169 (1901).

Weed, W. H., Ore-Deposits near Igneous Contacts, *Trans.*, xxxiii., 715 to 746 (1903).

3. *Descriptions of Contact-Metamorphic Districts of General Importance.*

Barrell, Joseph, Geology of the Marysville Mining District, Montana, *Professional Paper No.* 57, *U. S. Geological Survey* (1907).

Bayley, W. S., The Eruptive and Sedimentary Rocks on Pigeon Pt., Minnesota, and their Contact Phenomena, *Bulletin No.* 109, *U. S. Geological Survey* (1893).

Beals, Wm., Jr., The Seven Devils Mining District, Idaho, *Engineering and Mining Journal*, vol. lxix., No. 12, pp. 345 to 346 (Mar. 24, 1900).

Bergeat, A., Der Granodiorit von Concepcion del Oro im Staate Zacatecas (Mexiko) und seine Kontaktbildungen. *Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie*, vol. xxviii., pp. 421 to 569 (1909).

Boutwell, J. M., Arthur Keith, and S. F. Emmons, Economic Geology of the Bingham Mining District, Utah, *Professional Paper No.* 38, *U. S. Geological Survey* (1905).

Crosby, W. O., Limestone-Granite Contact-Deposits of Washington Camp, Arizona, *Trans.*, xxxvi., 626 to 646 (1906).

Harder, E. C., The Taylor Peak and Whitepine Iron-Ore Deposits, Colorado, *Bulletin No.* 380, *U. S. Geological Survey*, pp. 188 to 198 (1909).

Harker, A., and J. E. Marr, The Shap Granite, and the Associated Igneous and Metamorphic Rocks, *Quarterly Journal of the Geological Society*, of London, vol. xlvii., pt. 3, pp. 266 to 326 (Aug. 1, 1891).

Kemp, J. F., Copper-Deposits at San Jose, Tamaulipas, Mexico, *Trans.*, xxxvi., 178 to 203 (1906).

——— Review of *Bulletin* by Leith and Harder on Iron Springs District, *Economic Geology*, vol. iv., No. 8, pp. 782 to 791 (Dec., 1909).

Kemp, J. F., and C. G. Gunther, The White Knob Copper-Deposits, Mackay, Idaho, *Trans.*, xxxviii., 269 to 296 (1908).

Kellogg, L. O., Sketch of the Geology and Ore Deposits of the Cochise Mining District, Cochise County, Arizona, *Economic Geology*, vol. i., No. 7, pp. 651 to 659 (July–Aug, 1906).

Knopf, Adolph, Geology of the Seward Peninsula Tin Deposits, Alaska, *Bulletin No.* 358, *U. S. Geological Survey* (1908).

Leith, C. K., and E. C. Harder, Iron Ores of the Iron Springs District in Southern Utah, *Bulletin No.* 338, *U. S. Geological Survey* (1908).

Lindeman, E., Preliminary Report on the Iron Ore Deposits of Vancouver and Texada Islands, *Canadian Department of Mines, Mines Branch, Summary Report*, 1907 to 1908, pp. 35 to 43 (1908).

Paige, Sidney, The Hanover Iron-Ore Deposits, New Mexico, *Bulletin No.* 380, *U. S. Geological Survey*, pp. 199 to 214 (1909).

Prescott, Basil, Occurrence and Genesis of the Magnetite Ores of Shasta Co., California, *Economic Geology*, vol. iii., No. 5, pp. 465 to 480 (Sept., 1908).

Ransome, F. L., The Yerington Copper District, Nevada, *Bulletin No.* 380, *U. S. Geological Survey*, pp. 102 to 119 (1909).

Smith, George, Garnet-Formations of the Chillagoe Copper-Field, North Queensland, Australia, *Trans.*, xxxiv., 467 to 478 (1904).

Spurr, J. E., and G. H. Garrey, Ore-Deposits of the Velardeña District, Mexico, *Economic Geology*, vol. iii., No. 8, pp. 688 to 725 (Dec., 1908).

Stutzer, O., Die kontaktmetamorphen Kupfererzlagerstätten von White Horse in Yukon (Canada), *Zeitschrift für praktische Geologie*, vol. xvii., pp. 116 to 121 (1909).

Turner, H. W., Notes on Contact-Metamorphic Deposits in the Sierra Nevada Mountains, *Trans.*, xxxiv., 666 to 670 (1904).

Weed, W. H., The Elkhorn, Montana, Mining District, *Twenty-second Annual Report, U. S. Geological Survey*, pt. ii., pp. 419 to 510 (1900–01).

Yung, M. B., and R. S. McCaffery, Ore-Deposits of the San Pedro District, New Mexico, *Trans.*, xxxiii., 350 to 362 (1903).

4. *Miscellaneous.*

Blake, W. P., Superficial Blackening and Discoloration of Rocks Especially in Desert Regions, *Trans.*, xxxv., 371 to 375 (1905).

Clarke, F. W., The Data of Geochemistry, *Bulletin No.* 330, *U. S. Geological Survey* (1908).

Iddings, J. P., *Igneous Rocks* (New York, 1909).

Harker, Alfred, *The Natural History of Igneous Rocks* (New York, 1909).

Lawson, A. C., *Bulletin of the Department of Geology, University of California*, vol. iii., No. 17, p. 388 (1902–04). (Refers to Quartz Dikes.)

Spurr, J. E., Ore Deposits of the Silver Peak Quadrangle, Nevada, *Professional Paper No.* 55, *U. S. Geological Survey* (1906).

——— Igneous Rocks as Related to the Occurrence of Ores, *Trans.*, xxxiii., 288 to 340 (1903).

Stevens, H. J., *The Copper Handbook*, vol. vii. (1907).

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Sintering of Fine Iron-Bearing Materials by the Dwight & Lloyd Process.

BY B. G. KLUGH, BIRDSBORO, PA.

(New York Meeting, February, 1912).

In a paper before the Institute at Wilkes-Barre, Pa., June 1911,[1] Mr. James Gayley discussed the application of this process to iron-bearing materials. The same author[2] described the results of operations at the plant at Birdsboro, Pa.

The purpose of the present paper is to present further discussion of some technical details involved in the operation of this plant, and of the theoretical and practical relations of this product to blast-furnace practice.

Since Oct. 1, 1911, the Birdsboro plant has been in operation at the blast-furnace of the E. & G. Brooke Iron Co. The results have been highly satisfactory, although the material treated, being chiefly the flue-dust currently made by the furnace or taken from the accumulated stock-pile, was excessively high, and yet not uniform, in carbon, so that the desirable control or regularity of the amount of fuel in the mixture treated could not be maintained. Nothing could more forcibly demonstrate the flexibility of the process than the fact that, under these conditions, the sinter produced was, in all cases, of excellent quality.

The Dwight & Lloyd process, as such, and its present highly-developed mechanical appliances were described by Mr. Gayley in the paper above mentioned. While the repetition of some particulars will be unavoidable in this paper, it will be confined to features bearing upon the metallurgical principles involved.

According to the principle of the process, the finely-divided iron-bearing material to be sintered is intimately mixed with

[1] *Bulletin* No 56, Aug., 1911, p. 631.

[2] *Iron Age*, vol. lxxxix., No. 1, p. 73 (Jan. 4, 1912).

the amount of carbon requisite to produce the sinter. This mixture is then moistened and deposited upon the machine in a uniform layer, the upper surface of which is ignited by a small flame of intense local heat, and the combustion of the intermixed carbon is effected in a progressively downward course by a current of air flowing in the same direction through the permeable mass. The energy from the combustion of each particle of carbon is expended and utilized directly upon the adjacent particles of iron-bearing material, agglomerating them into a coherent sinter.

In other words, the Dwight & Lloyd sintering-machine is a piece of chemical apparatus in which to carry out the reaction between the oxygen of the continuous supply of air and the solid combustible material of the charge. The former is maintained in a zone of regular and continuous supply moving in the direction of gravity. The latter is, of course, intimately mixed with the material to be sintered. It logically follows that the capacity of the machine is limited by the weight of carbon burned per unit of time. It has been found that an amount of carbon equivalent to 8 per cent. of the weight of the ore to be sintered furnishes ample heat for the production of the sinter. Carbon in the mixture in excess of 8 per cent. performs the wasteful and deleterious functions of (1) consuming proportionately longer time for its combustion; (2) raising the temperature of the sinter produced to its fusing-point, thus enveloping unconsumed carbon; and (3) raising the temperature of the grate-bars and other parts of the machine. Besides which, the minimum consumption of carbon, consistent with maximum production and most desirable quality of product, is desirable for economic reasons.

From a given material, properly mixed with the correct percentage of fuel, the character of the sinter produced depends wholly upon the material itself, being unaffected by the speed of sintering or velocity of air-supply; but its amount per unit of time depends upon the rate of combustion of the intermixed fuel, which, in turn, depends upon the rate at which the oxygen is brought into contact with fresh fuel, as the inert products of combustion are taken away by the action of the fan.

Thus we come to the principle that the permeability of the bed of material, and the pressure-drop between the atmosphere

outside and that in the wind-box, determine—other conditions remaining constant—the rate of the production of sinter.

Permeability is largely influenced by the moisture added. The function of the water is not entirely understood. Primarily it causes a temporary agglomeration of the particles of the materials, thus preventing them from passing through the grates. The voids in the bed are then larger, offering less resistance to the gas-current. It must be borne in mind that the amount of added moisture is not a given percentage by weight, but the quantity required to produce a certain degree of plasticity. For instance, to a fine hematite there could be added 15 per cent. by weight of water, before the material would cohere properly; but with magnetite, 4 per cent. of added water produces the equivalent degree of plasticity. The regulation of this phase of the process, which is doubtless very important, has as yet been determined by rule-of-thumb only. This is done very well by ordinary workmen after a small amount of practice, especially upon a given material.

The diagram, Fig. 1, shows the relative arrangement of the product and crude material in the active sintering-zone. The rectangle represents a vertical cross-section through the pallets over the wind-box. The sinter and ore-mixture are seen to be separated by an imaginary line beginning and ending at two respective zero-points. This is about the state in case of sintering any material. When high-carbon materials are sintering, the combustion of the carbon proceeds downward, progressively. Should high carbon follow low carbon directly, the only adjustment necessary is to slow down the speed of the pallets, allowing greater time for burning out the excess of carbon. The only condition under which residual carbon is left in the sinter is when the temperature of the sinter in the upper part of the bed is raised, so as to render it incipiently fluid, and permit it to envelop small amounts of carbon. This only occurs when the carbon is excessively high, say, above 20 per cent.

In Mr. Gayley's article,[3] the tests showing the extent of desulphurization in sintering were noted. These were all made upon small samples, and belonged to the first trial of a particular material. There have been practically no high-sulphur materials treated which were not brought down as low in

[3] *Iron Age*, vol. lxxxix., No. 1, p. 73 (Jan. 4, 1912.)

sulphur as the best Lake ores. No special adjustment or preparation of the ores is necessary to effect desulphurization; the sulphur is eliminated simultaneously with the sintering. The desulphurization is not dependent upon the form or quality of the ore. Pyrites cinder has been brought down from 4.41 to 0.07 per cent., while magnetites have been lowered in sulphur from 3.50 to 0.15 per cent.

An analogy between the sinter made by the Dwight & Lloyd process and that of mill-cinder has been suggested. No such comparison is practicable. The two materials are wholly different in origin, appearance, and ultimate structure. Whenever mill-cinder or puddle-cinder has a small amount of entrapped gases, producing pores, the walls of the pores are glazed, and are therefore impervious to gases. In fact, the material is a glass, which has been completely liquid. The Dwight & Lloyd sinter, made under normal conditions, has never approached the

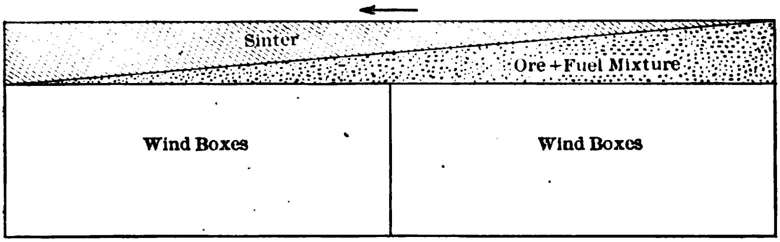


FIG. 1.—DIAGRAM SHOWING ARRANGEMENT OF MATERIAL IN THE ACTIVE ZONE—*i. e.*, THE PALLETS OVER THE WIND-BOXES.

liquid state, and hence its particles are united by plastic coherence of their surfaces; and the cell-walls have the microscopic porosity exceeding that of most easily reducible ores. The micro-photographs shown in Figs. 2, 3, and 4 very forcibly show the distinction among the structures of the cell-walls of the different materials.

Fig. 2 shows a section of heating-cinder; Fig. 3, puddle-cinder; and Fig. 4, the Dwight & Lloyd sinter, all of which are under a magnification of 40 diameters. The first two materials have been cooled from a liquid state. By its method of formation the heating-cinder approaches more nearly a theoretical ferro-silicate. The puddle-cinder, although containing practically the same chemical compound as the heating-cinder, has a different proportion of the same constituents. The

FIG. 2.—HEATING-CINDER.

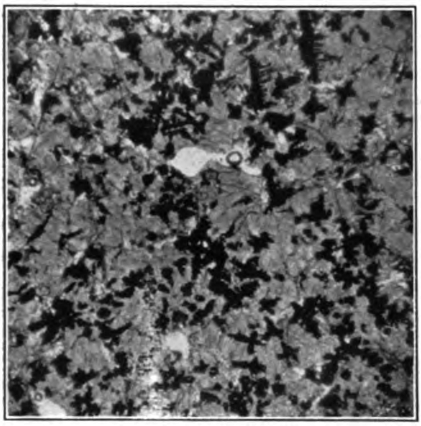


FIG. 3.—PUDDLE-CINDER.

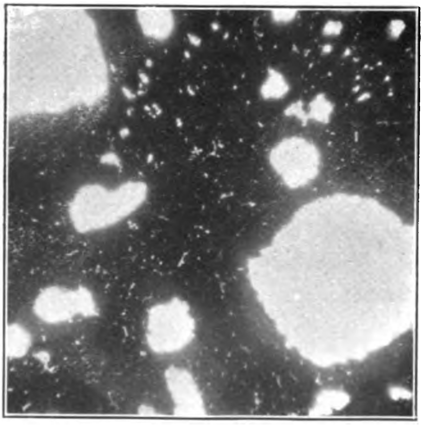


FIG. 4.—DWIGHT & LLOYD SINTER FROM FLUE-DUST.

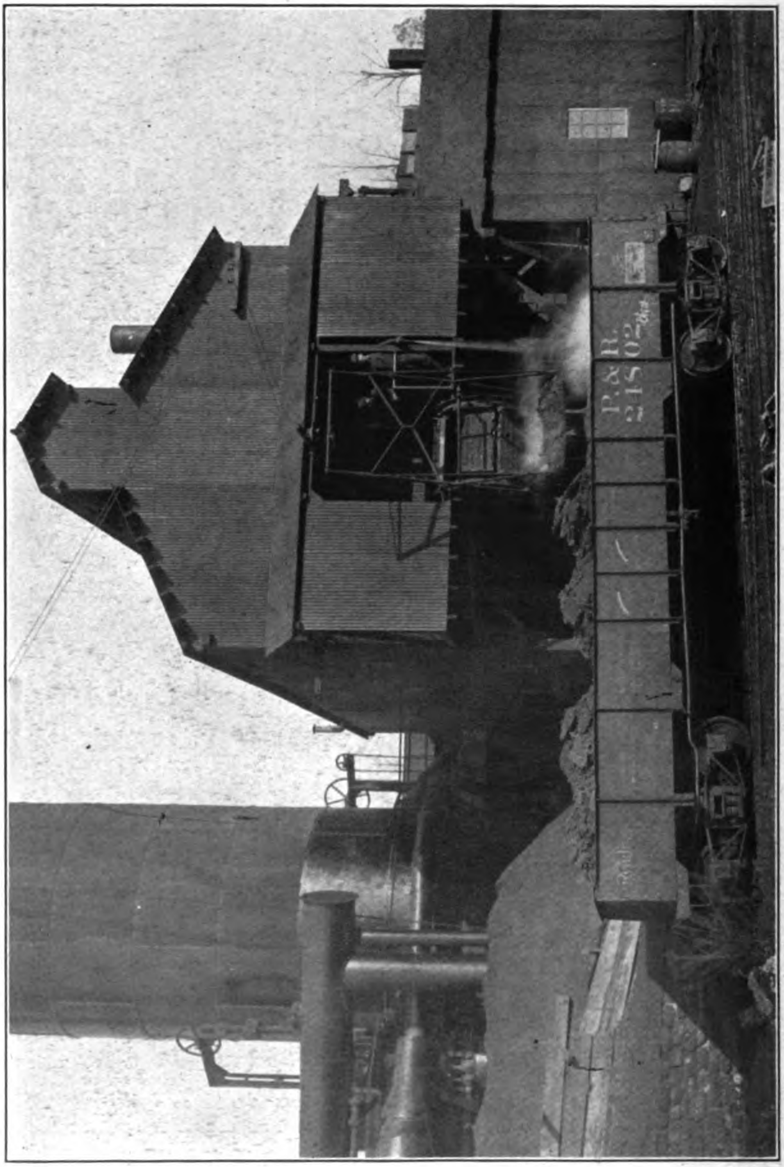


FIG. 5.—VIEW OF DISCHARGE-END OF FLUE-DUST CONVEYOR AND FINE-ORE SINTERING-MACHINE.

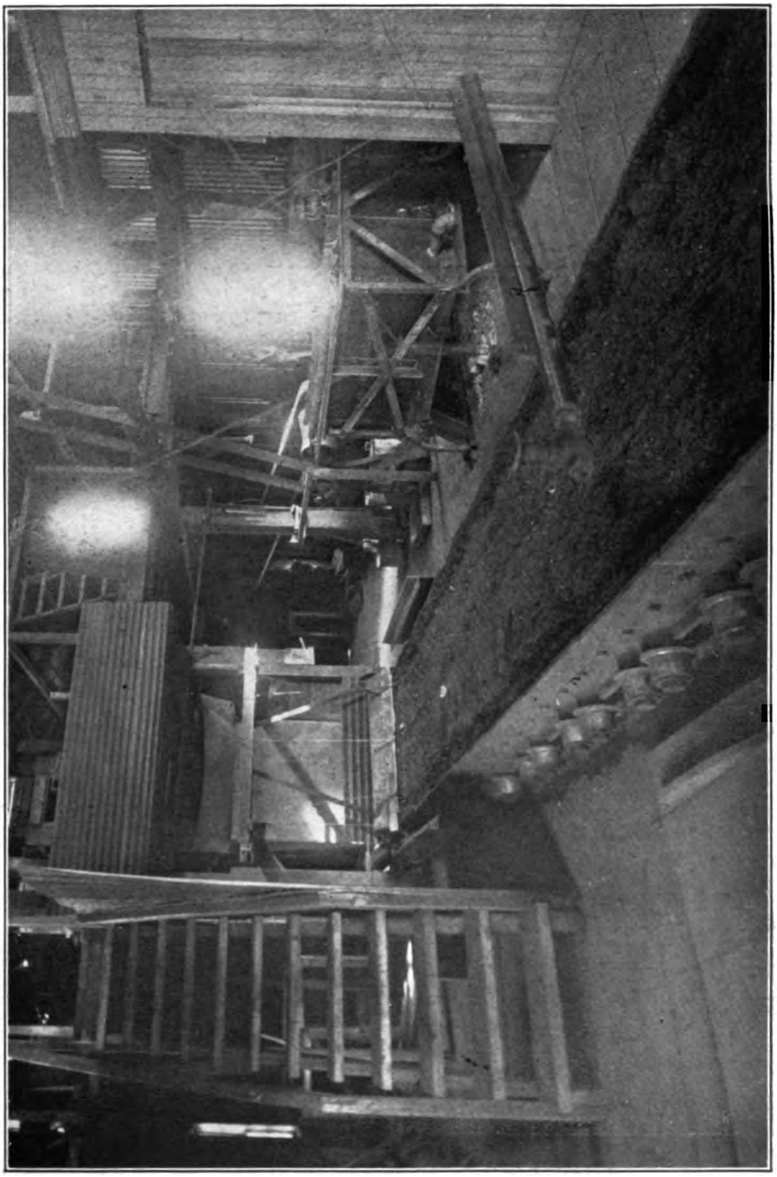


FIG. 6.—PALLETS CONTAINING SINTERED MATERIAL.

FIG. 7.—VIEW OF BLAST-FURNACE PLANT OF E. & G. BROOKE IRON CO., BIRDSBORO, PA., AND SINTERING-PLANT, SHOWING RELATIVE SIZE.

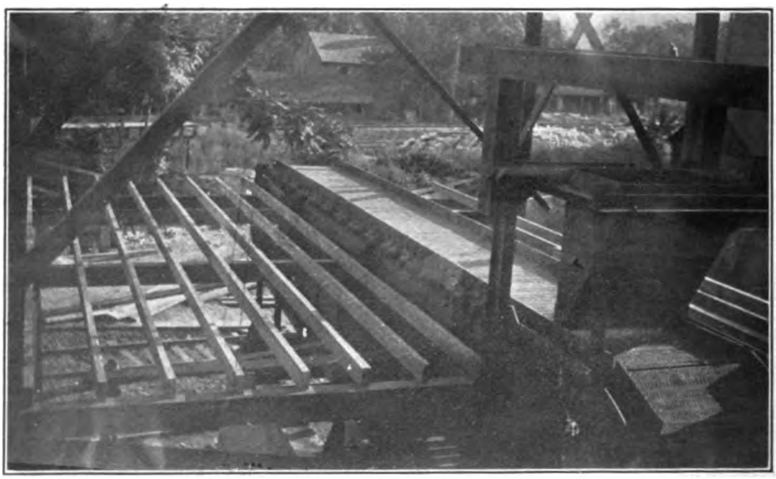


FIG. 8.—TOP OF ASSEMBLED SINTERING-MACHINE BEFORE COMPLETION OF BUILDING.

heating-cinder is further subjected to slower cooling and hence is allowed more opportunity for perfect formation of the crystals. The translucent and glass-like structure of the silicate of iron is shown in each case entirely enveloping the excess of the oxides of iron, which is shown opaque in each of the two cases. On the other hand, the section of Dwight & Lloyd sinter in Fig. 4 shows none of the translucent silicates whatever. But there is shown a uniform opaque mass indicating none of the glassy, silicate formation, which is characteristic of the two types of mill-cinder.

The pores in the D. & L. sinter are shown, all having the irregular lines forming the walls of the cells. When it is borne in mind that this section is magnified 40 diameters, the porosity of the structure as carried down into microscopic proportions, yet leaving sufficiently strong cell-walls, may be appreciated.

The practical furnace-manager may think it a long step from handling the tonnages necessary for average furnace-operation and such lengthy considerations of such minute structure, but all the furnace-reactions resolve themselves ultimately into microscopic proportions. Furthermore, this consideration is to show that there exists a positive distinction between the various forms of mill-cinder and Dwight & Lloyd sinter. However porous the mill-cinder may be, it can never approach in reducibility, the product under consideration.

Mill-cinder is a satisfied chemical compound, only giving up its oxygen at high temperatures, and then affording a minimum area of contact for reaction of reducing gases. Dwight & Lloyd sinter is a physical agglomeration of material treated, being bonded of particles of original size.

Several thousand tons of sinter have been produced at the Birdsboro plant and used in the blast-furnace. Figs. 5, 6, 7 and 8 are views of the furnaces and the sintering-machines at Birdsboro. At all times the sinter has shown itself a superior and beneficial material of the blast-furnace charge. By reason of variations in the ore-mixtures, no actual figures of the fuel-saving effected through the use of the sinter are available; but several times, as much as 10 per cent. of easily reducible Lake ores has been replaced by sinter; and the management unhesitatingly declares that taking off the ore and putting on the

sinter has the same influence on the fuel-consumption as would result from taking off entirely that amount of ore-burden.

At no time has there been any reaction in the furnace resembling that produced by mill-cinder. When mill-cinder is used with a burden of a high percentage of magnetic ores, a scouring action is often noted—especially when the mill-cinder is put on to the amount of 12 per cent. in one mass. There has never been at the Birdsboro furnace any scouring action or descent of unreduced oxides into the hearth since this sinter began to be used. According to all practical indications and theoretical considerations, there seems no doubt that a complete burden of Dwight & Lloyd sinter might be used advantageously.

The iron blast-furnace stands on a high plane as regards metallurgical efficiency, but there are yet vast opportunities for improvement. Not the least of these lies in the due preparation of ores and fluxes prior to charging.

Mr. Gayley, in his Institute paper, quoted from Schinz's book, *The Action of the Blast-Furnace* (1871), the following sentence:

> "A chemical action can only take place between two bodies, however great their affinity, if they are in intimate contact with each other; and the rapidity of this action will be so much greater, the more numerous the points of contact are."

Mr. Gayley's purpose in this quotation was to lay stress upon the advantage of the Dwight & Lloyd sinter over other materials in giving a greater area of contact to the gases in the reducing-zone. But the importance of this law is equal if not greater in its application to the reactions between solids in the fusion-zone. And this is where blast-furnace practice seems farthest from the ideal at present. Materials are charged in groups of tons, which can only perform their proper functions by combinations between minute particles. It then seems only logical to say that, if greater intimacy of arrangement were provided between the bodies forming slag, a distinct advantage would be gained, in that a slag of the desired chemical composition would be continuously formed in the zone of fusion. In present practice, there is an intermittent production—first of a basic, and then of an acid slag (or *vice versa*)—all finding their way into the hearth, and making up a final fair average, but certainly not constituting, in the strict sense of the term, a continuous chemical operation.

The natural consequence of submitting to zones of varying temperature mixtures of varying melting-points is a discontinuous and disproportionately wide zone of fusion. This source of irregularity is probably the source of many slips, scaffolds and other disturbances in furnace-practice.

As a possible remedy for these conditions, I would suggest a wider application of the Dwight & Lloyd sintering-process. Let us assume, as a hypothetical case, a mixture containing all-fine ores of any specific burden (say 40 per cent. of the entire ore-charge), and the flux for the entire burden (crushed to pass 10-mesh and under), to which the proper amount of carbon is added and sinter is produced. This sinter now contains: (1) the iron partly metallic and partly as either oxide; (2) the gangue and flux, not necessarily combined, but intimately associated and free from all CO_2. While the lime is thoroughly calcined, it differs radically from a separately calcined lime, in that it is so agglomerated with other materials as to remain solid, instead of slaking and disintegrating.

The advantages to be expected from the use of such material in the blast-furnace are:

A.—The solid mixture, containing uniform slag-constituents, will carry them unseparated to the bosh, where their function will be performed continuously, instead of interruptedly (by "running ahead" and segregating).

B.—All the CO_2 having been eliminated, the solution of carbon by ascending CO_2 will be avoided.

Hence, from the reactions,

$$CaCO_3 = CaO + CO_2; \ CO_2 + C = 2\ CO,$$

there will be effected a saving of carbon equivalent to 12 per cent. of the weight of the stone. Assuming conditions of 1,150 lb. of limestone per ton of pig; 96 per cent. of $CaCO_3$ in limestone; 85 per cent. of available carbon in coke; then:

1,150 lb. of limestone $= 1,150 \times 0.96 = 1,104$ lb. of $CaCO_3$.

$1,104 \times 0.12 = 132$ lb. of carbon saved.

$132 \div 0.85 = 155$ lb. of coke per ton of pig saved.

C.—An increased reducibility of the iron so treated. (This has been conservatively estimated as 5 per cent. better than the best available ore.)

D.—As a larger portion of the slag-forming constituents will

have already been combined, an amount of carbon representing the difference between the heat for fusion and the heat of formation will be saved.

E.—Uniform delivery of properly-proportioned materials to the different zones.

There has been set a numerical value for only the first case, as it is almost universally conceded that the carbon-solution factor is equal to the theoretical. Upon presenting this proposition to a well-versed student of blast-furnace conditions he said, "the furnace which does that will double its output." I do not claim such sanguine advantages as this, but I feel that an advantage would be gained far in excess of the expense of sintering the materials.

Materials otherwise regarded as unfit for the blast-furnace may be readily and cheaply converted into a product most desirable for that purpose. For instance, as considerable flue-dust carries an amount of carbon in excess of that required for sintering its own iron-bearing constituents, this may be used by mixing the flue-dust with blue billy or magnetites, thus giving a product of uniform, cellular composition without cost for fuel.

The Dwight & Lloyd sintering process thus offers to the problem of the conservation of our mineral resources a solution applicable to present economical and industrial conditions.

Discussion.

George W. Maynard: It is well known that there are many mangnetite-mines of which the ore is too low-grade for direct use in the blast-furnace. For carrying out the sintering process, the preliminary step, in the case of magnetites, is the separation of the ore from the gangue by magnetic concentration. The resulting fine-grain product is very objectionable in the blast-furnace, and when used must be a very small percentage of the charge.

The sintering process has saved the situation by furnishing a product which is absolutely ideal on account of its cellular structure.

(In reply to questions by W. J. Tudor, and Joseph W. Richards, the following additional information was given by Dr. Maynard.)

The percentage of iron in the product is determined entirely by the degree of concentration of the raw material and is practically not increased by the sinterating operation. The magnetic concentrates at Port Henry, and at the Benson and one or two other mines contain from 65 to 67 per cent. of metallic iron.

The cost of sintering is from 39 to 41 cents per ton of product, including superintendence, depreciation, and repairs. The itemized figures are about as follows: Mixing (including labor), 24; power, 9; ignition, 5; repairs, 3; total, 41 cents.

Professor Richards: From a metallurgical stand-point I question the accuracy of the statement on p. 517: "*C.*—An increased reducibility of the iron so treated. (This has been conservatively estimated as 5 per cent. better than the best available ore.)"

It seems to me that when a material is sintered in this way, the constituents present, as lime, silica, and alumina, have a chance to form a compound with the iron oxide; that such a compound, if formed before the material goes into the blast-furnace, will not be as easily reducible as the plain iron oxide itself, because the iron silicate, or whatever other combination of iron may have been formed during the sintering process, will have to be broken up; so that it does not strike me that the material can be as easily reducible as the unsintered material, or as the best available ore; the same objection, to my mind, would apply to the saving of carbon under the heading "*D*," in the formation of a slag. The formation of the slag from its constituents in the blast-furnace is a reproducing and recasting action, and if you produce the slag outside, you lose the heat of formation of the slag from its constituents in the furnace.

In making Portland cement, the formation of the cement is an exothermic reaction which helps the sintering, and if the slag is formed outside the furnace, I should say it would rob the furnace of some of the heat in the formation of the slag. Of course, I admit the slag will be more uniform and the furnace will run more uniformly, but I do not think that there will be any heat saved to the furnace because the slag is formed outside. This latter comment, however, would not apply to the treatment of magnetic concentrates, since the slag-forming

materials would be largely eliminated during the concentration.

Dr. F. W. C. Schniewind: As perhaps having a bearing on the question raised, Mr. Klugh says (p. 517): "This sinter now contains: (1) the iron partly metallic and partly as either oxide." The question arises, how much is metallic iron, because the metallic iron would not require any reduction. It is already in a metallic state, and the additional heat which the iron silicates will require may be offset by the metallic iron produced.

Arthur S. Dwight: In connection with some of the tests which have been made of this iron-sinter, it has been definitely determined that in some cases at least a small amount of metallic iron is formed, probably as spongy iron, more or less irregularly mixed with the oxides of iron, and probably some silicate when silica is present. As the iron in the silicate would be in the form of FeO, I might raise the question whether the reducibility of the silicate of FeO would not be greater than when the iron was present as Fe_2O_3 or Fe_3O_4.

Anton Eilers: It seems to me this could be easily settled. I believe in this sintering process FeO is formed, and as the material is at the same time very porous it takes a shorter time to reduce the FeO than it would Fe_2O_3. It is a fact that the sinter reduces very readily; at least, we find this to be the case in lead-smelting practice, where the same process is used for desulphurizing.

Henry M. Howe: One of the speakers has said what I wanted to say, that part of the oxygen is taken out and less work is done by the furnace. The mechanical condition of the ore is changed, so that the reduction can take place more rapidly with less fuel.

There is one statement which I think must be meant in a different way from what one would first take it. On p. 515 it is said that "taking off the ore and putting on the sinter has the same influence on the fuel-consumption as would result from taking off entirely that amount of ore-burden." That is to say, you would infer from this, that the sinter is reduced without the

consumption of any fuel, which, of course, is not what it meant.

MR. DWIGHT: The case referred to by Professor Howe was a replacement by sinter of a small portion of the ore-charge, and the effect of substituting this very open, porous, and readily reducible material was so beneficial that the fuel-charge present could be much more effectively utilized, and it was able to carry just that much additional burden. Naturally, we should expect to reach the limit of this possible increase of burden when the fuel came to be utilized to the best possible advantage.

In the case of lead- and copper-smelting, in which this sintering process is being rather extensively used, as mentioned by Mr. Eilers, it has been found that the fuel required for smelting can be lowered as much as 15 or 20 per cent., and yet give equally good, if not better, metallurgical results, with a notable increase in the tonnage smelted by the same furnace.

To express the matter in another way, under ordinary lead-smelting conditions, the coke used would equal about 12 per cent. of the ore-charge, but when the charge contains a considerable proportion of sinter, this fuel-percentage can be reduced to 10 per cent. very easily, and sometimes very much under 10 per cent. The effect on the behavior of the furnace is quite marked, and can be readily accounted for by the unique physical properties which are peculiar to this product, among which may be mentioned the intimate mixture or propinquity of the elements to be smelted, and the porosity or cellular character, which gives the reducing-agents ample scope, and enables the blast to penetrate to every part of the charge.

Comparing the Dwight-Lloyd product with the product of older forms of pot-roasting, the former is found to have a very much greater reducibility; thus, in lead-smelting, the furnace which will show a speed of 100 tons a day of the ordinary pot-roasting product, will frequently smelt as much as 140 tons per day when the pot-product is replaced by Dwight-Lloyd sinter, as has been freqently demonstrated, all other conditions being identically the same, furnace, ores, fuel, and men.

With regard to the percentage of metallic iron present, there have been some analyses made of sintered iron-ore and

iron flue-dust which show the relative proportions of FeO and Fe_2O_3, but I do not remember seeing any that have reported the metallic iron that was present as such. It has been observed, however, in certain cases where samples of the sintered product have been carefully broken up with a hammer, that small particles of metallic iron or iron sponge were present.

H. M. Chance: May there not be a double action, first a reducing action, resulting in the formation of metallic iron, and as the carbon is burned out and the mass is cooling, may not a reoxidation of that metallic iron take place?

I ask if any investigation has ever been undertaken to determine whether this action does take place, whether there is a reduction followed by a reoxidation?

Felix A. Vogel: During this discussion nothing has been mentioned as to what forms the cementing action in this process. An inspection of the samples here exhibited will show that it is due to slag-formation, and not to any reduction of the iron-ore, either to metallic iron or to any form of oxide. It is merely a silicification forming a double or triple silicate of lime and iron. An examination of the sintered material under a microscope will readily show small globules of glazed metal, which covers the material. To my mind, this glassy cover will render the material less easily reducible than has been stated; in fact, it will take additional carbon in the blast-furnace to reduce this glaze, and to bring the iron oxide in whatever oxidation it may be—whether FeO or Fe_3O_4, or whatever it may be—in contact with the reducing carbon or reducing gases.

E. Gybbon Spilsbury: The samples of the sintered ore here exhibited do not appear to show any fines. Are any fines formed as the sinter is discharged from the grates, and if so, what is the percentage that must go back to the machine to be resintered, or else be charged to the furnace as fines, thus lessening the advantages which could be gained if it were all in lump form?

Professor Maynard: I have observed the work at Birdsboro on several occasions, and I have asked that very question which you have propounded. I am told that none has gone

back for re-treatment. Of course, there is a certain dropping through the grate, a certain amount of breaking up, but I do not know that any has ever been carried back. During my observation on the few days that I have been there, I have not heard of that difficulty.

MR. DWIGHT: In order to determine the average size of the product resulting from treating flue-dust, I made a test on the second day the plant was started up at Birdsboro. On account of the large amount of carbon present in the flue-dust, which has to be burned out, there is a considerable amount of internal shrinkage, much greater than occurs when an ore like magnetite or hematite is used, where the exact percentage of fuel necessary to do the work can be added.

The product which results from the treatment of flue-dust remains in the form of a solid cake until it is discharged from the machine, and then it tends to break up into crab-shaped masses or aggregations similar to the samples here shown. These aggregations are of various sizes, from pieces twice as large as the fist down to very small sizes. In order to determine the relative proportions I made the following experiment: the machine was stopped, the finished product carefully scraped off from several of the pallets, and the fragments classified into several sizes by a rough hand-sorting, throwing into one pile those pieces which were larger than a 2-in. ring, into another pile those that would go through a 2-in. ring, into another those which would go through a 1-in. ring, and also the pieces which would go through a 0.5 in. ring, and everything below that was screened through a 0.25-in. screen, and passed through a consecutive series of screens down to 120 mesh, and the various sizes were weighed and the percentages calculated. The proportion of each of the sizes coarser than 0.25 in. was from 20 to 30 per cent., and of the entire mass, nothing being lost, 98 per cent. remained on a 0.25-in. screen, and 2 per cent. passed through. Of that 2 per cent. which passed through the 0.25-in. screen, one-half remained on a 10-mesh screen, and one-half passed through.

When the process is conducted with a proper proportion of moisture, proper ignition, proper mixture and distribution on the machine, there should be practically no "fines" in the

everyday practical sense. When irregularities occur, as they sometimes will, irregular spots will occur, and these will sometimes produce "fines." The amount that goes through the slot of the grate-bar is exceedingly small. In the course of a day there will accumulate, in the suction-box, perhaps a wheelbarrow full or two, which is cleaned out at the beginning of the shift and simply put back into the bins to be re-treated. It does not amount to enough to be considered serious. However, if on account of some peculiar condition an undue quantity of fines should be produced, it is very easy to keep it out of the final product by having the machine discharge on a grizzly which will deliver the coarse product into the cars, and the fines can be automatically returned to the machines.

There should be less fines made when sintering magnetites or iron concentrates than when flue-dust is being treated. The carbon in the flue-dust is apt to run quite irregularly, so that frequent changes in adjustment may be necessary to maintain a perfect product. In the regular Dwight & Lloyd practice each fundamental requirement of the process is controlled by a separate mechanical attachment; so that the proportion of fuel in the charge, the permeability of the ore-bed, the volume and pressure of the gases, the degree of ignition, the percentage of moisture, the time of sintering, etc., can each be separately and immediately modified without disturbing any of the other adjustments. Thus, it is possible to keep the operation at all times up to the highest degree of efficiency and thereby secure not only low costs but uniformly satisfactory product.

Dr. N. S. Keith: Is the material magnetic, or attracted by the ordinary permanent magnet? I believe the material would be affected by strong magnetism. I would like to know whether it can be attracted or deflected under ordinary permanent magnetism, making it a sort of standard of strength of magnetism?

J. L. W. Birkinbine: I made a trip to Birdsboro, and I was interested in the product, and tried the effect of an ordinary horse-shoe magnet on it, both on the product from the flue-dust, as sintered flue-dust, and also on some magnetic concentrates. I spoke to Mr. Dwight this morning, and said that the

sintered magnetic concentrates did not seem to be as magnetic as the unsintered material, and I desired an explanation, which he could not give me at the time, but still the product was sufficiently magnetic to be attracted by an ordinary magnet.

There was one point which Mr. Vogel brought out, that I desire to speak on, and that is the point in connection with the sintering, whether it was due to some form of fluxing or fusing, and I am inclined to believe his specification is correct, as the report of the attendant in charge—Mr. Dwight was absent at the time—was to the effect that it required more fuel to sinter a magnetite concentrate than was required for flue-dust, and I promptly assumed that the cause of this was that the flue-dust carried considerable sulphur, and was bound together by the partial fusing of silicates, while the magnetic concentrates really carried very little gangue, and required some melting of the ferric oxide.

Prof. H. O. Hofman (communication to the Secretary *):—In the discussion of sintering fine iron-ores the question of what caused the agglomeration of particles was considered in a general way. The following notes contain some thermal facts bearing upon the subject.

The leading factors in the sintering of ores are temperature and composition of charge.

As regards temperature, A. S. Dwight stated to me that in sintering finely divided iron-ore or flue-dust, with the Dwight-Lloyd machine, the heat was apparently about the same as in blast-roasting sulphide ore. Laboratory-experiments carried on with the Savelsberg process [1] in 1907 have shown that the highest temperatures obtained range roughly between 1,000° and 1,200° C.

The ore-charge contains oxides of iron, gangue, and coke. Ferric oxide fused, according to Kohlmeyer,[2] at 1,565° C.; that is, at temperatures much higher than those reached in the sintering process. There must be present a binder for the iron oxides, and this can be either a ferrite or an iron silicate. The only ferrites that need consideration are calcium ferrites. Kohl-

* Received Mar. 7, 1912.

[1] Hofman, Reynolds, and Wells, *Trans.*, xxxviii., 126 (1908).

[2] *Metallurgie*, vol. vi., No. 10, p. 323 (May 22, 1909).

meyer and Hilpert,[3] who traced the freezing-point curve, found that while with some mixtures of CaO and Fe_2O_3 sintering was noticeable at 900° C., the practical temperature lay at about 1,200° C. This temperature furnished also the lowest liquid fusion, namely, that of a mixture of 1 mol. CaO and 1 mol. Fe_2O_3, 26 per cent. CaO and 74 per cent. Fe_2O_3. Calcium ferrites may therefore act as binders at sintering temperatures.

As regards silicates, I determined,[4] in 1899, the formation-temperatures of various ferro-calcic silicates. The pure ferrous singulosilicate forms at 1,270° C., the sesquisilicate, $3FeO.2SiO_2$, at 1,140° C., the bisilicate at 1,110° C.; by substituting CaO for FeO, the formation-temperatures are lowered to the minima, 1,130°, 1,070°, and 1,030° C., respectively, when by further substitutions the temperatures rise again. The minima lie well within the ordinary ranges of temperature obtaining in the sintering of finely-divided ore.

The conclusions to be drawn are, that in the sintering processes the agglomeration of the ore-particles is due mainly to the formation of ferrous silicate, and to a smaller extent to that of a calcium silicate.

In our experiments we used chemically-prepared calcium sulphate and barium sulphate, but we did not test the corresponding minerals, gypsum and barite. I believe there is a difference in the decomposition-temperatures of a prepared salt and a salt of the same composition occurring as a mineral. Magnesium carbonate, for instance, is of this character. The investigation of O. Brill[5] shows that prepared normal magnesium carbonate begins to give up some of its carbon dioxide at 265° C., while a specimen of crystallized magnesite was decomposed at 445° C.

---

[3] *Metallurgie*, vol. vii., No. 7, p. 193, and No. 8, p. 225 (Apr. 8, 22, 1910).

[4] *Trans.*, xxix., 682 (1899).

[5] *Zeitschrift für physikalische Chemie*, vol. xlviii., p. 283 (1905).

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Agglomeration of Fine Materials.

BY WALTER S. LANDIS, SOUTH BETHLEHEM, PA.

(New York Meeting, February, 1912.)

THE earliest example of attempting to form finely-divided materials into larger masses for better adaptation to commercial use was probably the briquetting of peat and lignite-waste at Paris by the use of a clay binder. It was from this attempt that our word briquette has arisen (Fr. *la brique*), the formed masses being shaped similar to ordinary bricks. This term does not, however, lend itself to the many shapes of such formed material as are now being produced, as few of them aside from some of the European brown-coal products bear any resemblance to the shape of that well-known article. The term "agglomeration" has therefore been chosen as more accurately descriptive of the products now being manufactured, this term including the molding as well as the sintering.

With the increasing prices of fuel and ores and the greater demand for economy in the operation of industrial plants, more attention has been paid in recent years to the utilization of waste products and low-grade ores and fuels. Much of the waste has been occasioned by the inability to utilize finely-divided ores and fuels in the furnaces because they could not be kept there, or else because they clogged up the furnace-shaft so that gases could not be forced through under ordinary conditions of operation. As a result, all such fines were thrown on the dump. Again, with the exhaustion of the richer deposits of ores, concentration of lower-grade ores becomes a necessity, and most concentrates are produced in a finely-divided condition. Aside from these considerations, there is also the economy in the cost of operating the plant; a furnace running on agglomerated material will have a much greater output than one working on fines. In one instance the charge of an iron blast-furnace was changed from fine concentrates to briquettes and the output was increased four-fold; better results could have been obtained had facilities been at hand for taking care of the increased output.

To attempt to catalogue all the materials that have been agglomerated by one or another process is manifestly impracticable, and I give here a list of only a few of the more important ones at present attracting attention:

I. *Fuels.*—In the mining and preparation of fuels like coal and lignite much fine material is produced. Also, certain lignites slack and fall to pieces on storage. The agglomeration of these fines has long been practiced in Europe, where fuel is scarce and expensive, and the U. S. Geological Survey and the Bureau of Mines have been active in calling attention to this phase of conservation of our own fuel-supplies.

II. *Concentrates.*—The shaft-furnace, when fed with lump material, is probably the most economical of our smelting-devices. Also, the economy incident to the smelting of pure ores in such a furnace is too well known to merit discussion here. This has led to a wide application of ore-dressing to prepare such pure material; and since nearly all dressing-operations require more or less fine crushing of the ore, it is almost a necessity that some agglomerating-device be used to prepare the concentrates for advantageous use in the blast-furnace. In the United States the agglomeration of magnetite concentrates has received considerable application.

III. *Fine Ore.*—Years ago many of our ores, particularly those of iron, were plentiful and cheap. Furnace-men would not accept fines, and as a consequence large quantities of this material accumulated at the mines and the furnaces. With the increasing cost of ore the heaps of fines all have increased in value and may be profitably agglomerated and sold. Moreover, the long hauls and frequent trans-shipments necessary with many ores in the United States cause much breakage, and this condition opens up another field for the industry.

IV. *Flue-Dust, Sweepings, Etc.*—The disposal of the dust carried out of blast-furnaces has frequently offered a disposal problem quite in keeping with the actual intrinsic cost of the dust to be handled. The agglomeration of this material, together with the sweepings of the plants, is now attracting the attention of furnace-operators, and great saving would be attained by again charging such material back into the furnace in such form that it will not be blown out. In the year 1910 the United States produced nearly 28,000,000 tons of pig-iron.

A conservative estimate of the flue-dust made by the blast-furnaces in the same year is 3,500,000 tons, carrying at least 35 per cent. of iron. At a low value of 4 cents per unit of iron, this dust cost almost $5,000,000 for its iron-content alone, not to mention another $1,500,000 worth of coke contained in it. Surely a process that would enable one to utilize this enormous by-product is worth attention.

V. *Scrap-Metal.*—Even finely-divided scrap-metal, such as filings, chips, etc., is now being formed into briquettes for more efficient handling. Sometimes flue-dust, sweepings, etc., are agglomerated together with the metal, the whole making a mass possessing many advantages in certain branches of metallurgical treatment.

No single method of procedure is applicable to the treatment of the widely-different materials listed in the above five classes. In fact, the diversity of the agglomeration processes used makes it somewhat difficult to outline a simple classification which will be comprehensive, and the classification here proposed may sacrifice completeness for simplicity.

In general, the agglomeration processes may be divided into:

I. Those utilizing certain properties in the material for producing the desired coherence.

II. Those obtaining coherence through the addition of a foreign substance or binder.

Under Group I. are four classes:

1. Certain materials, when moistened with water and molded into form and dried, possess considerable coherence. Ores carrying soluble salts, clay, easily-hydrated compounds, etc., are frequently found amenable to this simple treatment. A few iron-ores and roasted products are actually treated in this manner, but the product possesses the great disadvantage that on heating to a temperature sufficiently high to drive off the water the briquettes fall to pieces.

2. Pressure greatly assists in developing the cohering-power of many materials; probably if a high enough pressure could be uniformly applied throughout the mass to be formed all substances would agglomerate under this treatment, but the use of pressure alone is limited to but very few cases in practice. Sometimes the best results are obtained on dry materials, sometimes a certain amount of moisture is necessary; the pressure so far used runs up to about 2,000 atmospheres.

3. All materials on being heated to a high enough temperature pass through a pasty or semi-fused state and cohere to such a degree that on cooling a more or less firm mass results. This phenomenon is called sintering. If done in a rotating furnace or rotary kiln the sticky masses roll together like snowballs, and small round particles are formed, which are called "nodules;" the process is called "nodulizing."

This sintering property of a material may be taken advantage of by molding the material into briquettes, using only a slight pressure to insure filling the mold, then burning the briquette so formed at a temperature that will insure cohesion. This is the principle of the well-known Gröndal process.

4. This class is represented by processes employing a combination of pressure and sintering. It is difficult to fix exactly the limits which differentiate a process truly belonging to this fourth class from one of the third, since the difference is wholly in the degree of pressure employed. I have chosen arbitrarily to place in this fourth class all processes which use pressures exceeding 30 atmospheres for the formation of the briquette. The best example of this fourth class is the originally Ronay process as installed at Catasauqua, Pa., in 1904. The Ronay process has since been modified by limiting its application to ores which will agglomerate under high pressure alone, without the necessity of afterwards sintering them.

Under Group II. are included the greatest developments of the briquetting processes. The use of a binder much simplifies the whole operation, as the binder acts as a cementing medium to hold the inert particles of material together. It is almost impossible to list all the binders that have been used; a few of them are, clay, lime, ground slags, natural and Portland cements, water-glass, kieselguhr, carnallite, tar, pitch, asphalt, petroleum, sulphite residues, naphthaline, paraffine, molasses, resin, starch. Most of these act of themselves if the precaution is taken to insure a thorough mixing with the material to be briquetted. Others require that the briquettes be aged, or even heated after formation to temperatures up even to redness.

The operations of Group II. may therefore be divided into three sub-classes: (*a*) Processes in which the binder is mixed with fines and molded under low pressures; (*b*) processes in which higher pressures are used along with the binder; (*c*)

processes in which a binder, and possibly pressure, are used, with a subsequent heat-treatment. The first two are self-explanatory; the last may be sub-divided into processes which use a baking in superheated steam, or even agglomerating in a furnace, as, for instance, when lime is added and later the briquettes are passed through an agglomerating-furnace.

It seems to me that proper attention has not always been paid to the selection of a binder for the particular case at hand. Too often is the intrinsic cost of the binder itself the main item in its selection, the subsequent costs it entails in passing through the smelting- or refining-furnace being entirely overlooked. The waste-product possessing binding-power may become very costly if it entails the production of an extra amount of slag to be smelted, or introduces in the furnace-product a small amount of impurity which is difficult to remove afterwards. Where limestone is an essential ingredient of the furnace-charge lime can be profitably used in considerable quantities as a binder. If the materials are self-fluxing a minimum of binder should be used, no matter what its composition may be.

Pressure increases the effectiveness of all binders, enabling one to obtain the desired results with the use of a minimum of extraneous material. Around metallurgical works, where power is usually cheap, an extensive investigation of the most economical balance between binder and pressure should be carried out. The importance of the industry is such that soon some enterprising briquetting company will erect a central testing-plant similar to an ore-testing laboratory, and such questions as arise will be absolutely settled for each particular case at a minimum of expense.

The physical properties which a briquette should have may be summed up as follows:

It should be strong enough to stand handling without undue breakage. The simplest test to determine this property is a drop-test. A number of briquettes should be dropped from a height of at least 6 ft. upon a hard stone surface. Not over 25 per cent. of the number so dropped should break, and none of the broken ones should go to powder of the original texture of the material before briquetting. The breaking of a briquette into two or three pieces is not a serious matter, but in no case should it pulverize.

Where the agglomerated material is to be stored or transported before use a weathering-test should be applied. Storage in the open which subjects the agglomerated material to rain, snow, frost, and sunshine should be resorted to, since none of these agencies should affect a well-made product.

For proper reduction in the shaft-furnace the agglomerated material should be porous. Where briquettes are to be tested, the dropping of water from a measuring-device upon a briquette of known volume gives a fair test, if care be taken to do it slowly and carefully, so that no more water is measured out than is absorbed by the mass. A simpler and easier test is made by weighing the agglomerated mass and submerging it under water for at least 24 hr. and again weighing. The displacement of the entrapped air may be hastened by performing the operation under a vacuum. A good briquette should show a porosity of 20 per cent.; that is, it should take up water to the extent of 20 per cent. of its volume. One of the greatest drawbacks to the nodulizing process is that the nodules are non-porous, and therefore difficult to reduce. The addition of lime to the charge of the nodulizing-kiln somewhat counteracts this tendency to form non-porous nodules, but unless carefully made the nodules will not withstand some of the other tests recommended.

Disintegration should not follow the exposure to water-vapor at 150° C. (300° F.), because the top of a blast-furnace contains vapor at this temperature. The test for disintegration is best performed by submitting the briquette to a steam-pressure of 60 lb. per sq. in. for several hours. Care must be taken to submit briquettes containing certain binders to this test, since some of them will fall to pieces under the action of hot water-vapor.

Briquettes should not disintegrate when heated to redness. This test can best be done in a muffle, and if conditions permit should be in an atmosphere of carbon monoxide and dioxide. Many of the hydrated briquettes, or those bound together by hydrating influences, will not stand this test.

Of course, it is understood that no briquette should contain a binder that exerts a harmful influence on the product of the furnace. No sulphur-compound, for instance, should ever be introduced into a briquette to go into an iron-furnace.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Sintering and Briquetting of Flue-Dust.

BY FELIX A. VOGEL, NEW YORK, N. Y.

(New York Meeting, February, 1912.)

FLUE-DUST, to most blast-furnace operators, means a troublesome by-product, the formation of which should be curtailed, if not prevented entirely. However, with the increasing use of fine ores, larger furnaces, and high-pressure blast, the production of flue-dust is constantly increasing, and amounts annually in the United States to from 3,000,000 to 3,500,000 tons, an exceedingly high tonnage, of which a large part has been discarded as valueless.

As a result of greater economy in the iron industry, the attention of our furnace-men has been directed towards the utilization of this enormous amount of waste material, a problem which had also been given due consideration by metallurgists abroad.

Flue-dust is generally a fine material containing considerable coke and iron-ore, with a small admixture of lime and silica, depending upon the burden. The iron-ore is partly reduced, which shows that the dust originates largely in the reducing-zone of the blast-furnace.

In the United States this dust usually contains 20 per cent. of coke and more than 40 per cent. of iron. Estimating coke to be worth $3.25 per ton, and iron-ore 7 cents per unit, a ton of flue-dust, unless made available, represents a loss to the furnace-man of $3.50. This accounts for the first efforts to recharge the flue-dust into the furnace, either by moistening it down with an excess of water, or mixing it with clay to form balls of pulp, or treating it with lime-water.

These methods, however, have been practically discarded, as they failed to produce the desired economies.

To recover, in the blast-furnace, all the values represented by the material contained in the flue-dust, the following conditions should be complied with :

1. The dust should be agglomerated into lumps about the size of furnace-coke, so that it will help to carry the burden and facilitate the flow of the gases.

2. The agglomerated material should be strong enough to carry the burden without disintegrating; it should be heavy, so as to decrease its volume, and it should be sufficiently porous to permit the furnace-gases to penetrate fully. Under no condition should the surface be glazed.

3. It should contain all of the valuable constituents of the dust, such as coke, iron-ore, lime, etc.

4. It must stand handling, without undue breakage, and should not produce more than 5 per cent. of dust.

5. It must stand the weather.

6. It must not disintegrate in the blast-furnace before being greatly or totally reduced.

7. It must submit to easy reduction without requiring additional fuel.

8. It must not contain substances detrimental to blast-furnace operations.

9. Its cost of production must be low.

Blast-furnace operations, by the use of such agglomerated material, will result in

1. Regular steady operation.
2. Increased burden, with increase in the metal produced.
3. Decrease in the consumption of coke.
4. Decrease in the production of flue-dust.
5. Decrease in the cost of producing pig-iron.

In order to obtain these results American and European metallurgists have followed two different lines. In the United States it has sufficed to save the iron-content only (though not in the best possible form), while abroad the endeavor has been to make a high-class product which would meet all the conditions above enumerated.

A number of processes have been evolved in the United States, generally known as agglomerating and sintering processes. They are based on fritting together the particles of ore by heat, the binding action being due to the formation of silicates, mostly of iron. When the coke has not been eliminated mechanically from the dust, it is burned out, leaving ash in the agglomerated material, which increases the formation of

silicates of iron or glazing-material. In some cases, however, more fuel is added to the flue-dust, which, naturally, further increases this drawback.

The nodulizing process, the oldest process in the United States, has been in successful operation for a number of years.

Flue-dust is either treated directly, or it is previously submitted to a magnetic separation to eliminate coke and lime. This is done to facilitate the subsequent nodulizing-operation, which is carried on in a slowly-rotating cement-kiln from 80 to 120 ft. long. From 200 to 300 lb. of finely-powdered coal is used per ton of finished material, the coal being blown into the kiln. Gas and oil have also been tried with more or less success.

The heat produced is considerable and difficult to control, the semi-soft material formed consisting of iron-ore particles and slag, which, by the revolving action of the kiln, is balled together in nodules of various sizes—from a pinhead to that of a cannon-ball—which are usually quite dense, often fused and glazed. They contain from 60 to 67 per cent. of iron, which makes them quite attractive from the furnace-man's point of view.

To make nodules an elaborate and expensive plant is required, the operation of which is more or less difficult and costly.

The Huntington-Heberlein pot process, which has been used with good results in the roasting of pyrite-cinders, has been recommended for the fritting of flue-dust. The resulting fritted material is of more or less cellular structure. However, this would not be an advantage, as the surface would be largely glazed, rendering it not permeable to gases, and would have to be removed in the blast-furnace at about smelting-heat.

The process is somewhat simple, requiring stationary iron pots fitted with a perforated false bottom through which the air is blown into the charge. The equipment is cheap; the operation, however, is not continuous, which makes it expensive.

The Gröndal briquetting process has also been applied to flue-dust. The flue-dust, either moistened, or after the elimination of the coke and stone, is pressed into bricks, which are subsequently fritted in high temperature. To facilitate the

operation it was found necessary to eliminate the coke; this, however, increases the cost. The separated coke is of little value, since it contains many impurities. The presses used are ordinary brick-presses. The bricks are carefully placed in layers on cars, which are run into long kilns about 170 ft. long, where they are submitted to high heat, gas being used for the purpose. The platforms of the cars are built of fire-brick and form the bottom of the kiln. The highest temperature, about 1,300° or 1,400° C., is reached in the center of the kiln, the highly-burned briquettes working gradually towards the cooler end of the kiln, where they are finally unloaded. The operation lasts about 7 hr. The resultant briquettes contain from 65 to 70 per cent. of iron with practically no impurities, these having been eliminated. No ashes are left by the fuel. The briquettes are only slightly fritted, are very porous and friable, and make a high-class material for use in an open-hearth furnace.

The manufacture of Gröndal briquettes is expensive, necessitating a costly plant, which has limited output.

A ton of flue-dust will produce about two-thirds of its weight in briquettes.

Quite recently the Dwight-Lloyd process has been applied to the sintering of flue-dust. The material is submitted to internal combustion in layers from 5 to 7 in. thick. It is fed on an endless conveyor formed of iron pallets or grates. After the fuel contained in the flue-dust has been ignited by means of a gasoline torch, or some other device, the air is drawn through by suction. The operation lasts about 20 minutes.

A good deal has been published of late in regard to this process. It is claimed that the required plant is not costly, while the operating-expenses are considerably lower than in the previous process. The resultant sintered material is not homogeneous, and, while a large portion of it is of cellular structure, it is glazed on the surface, which makes it quite difficult to reduce in the blast-furnace.

The Greenawalt process uses much the same apparatus as the Heberlein pot process, but air is drawn through the charge as in the Dwight-Lloyd process.

The sintered material from these various processes is expensive on account of the loss of carbon, and, with the exception

of the Gröndal briquette, is not of good physical structure and is usually glazed on the surface.

The briquetting of flue-dust has been more attractive abroad than has the sintering.

The lime process mixes the flue-dust with from 5 to 10 per cent. of hydrate of lime. After briquetting, the material is exposed to the air for a certain length of time, so that a carbonate is formed, which is the binding medium. This binder will eventually act as flux and replace a certain amount of stone. The process, while having decided advantages, is quite cumbersome and costly, as the briquettes must dry from two to four weeks under cover.

The Pioneer process uses sulphite pitch (obtained from the sulphite pulp-mills) as a binder. It is an organic substance, rich in carbon and hydrocarbons, which will burn readily and thus increase the caloric value of the material. The flue-dust is pressed into briquettes with from 4 to 8 per cent. of sulphite pitch; they are quite hard and give fair results, but the process is expensive.

The Ronay process does not use a binder. The flue-dust is submitted to a very high pressure in a specially-constructed type of hydraulic press; the resulting briquettes can be handled immediately and have proved very satisfactory. The process requires an expensive plant, however, increasing the operating-cost.

The Schumacher process does not use what may properly be called a binder, but is based on the latent cementing actions existing in fresh flue-dust and which are made active by the presence of a small amount of a catalytic substance. Thus 0.25 per cent. of magnesium chloride mixed with fresh flue-dust and from 6 to 10 per cent. of water, pressed into briquettes, will create a strong reaction, noticeable by the considerable heat developed; the briquettes will be perfectly set and hard within a few hours. The process is very simple, an ordinary pug-mill being used in which to mix the material, which is subsequently pressed into briquettes in a toggle-press and then loaded on cars to allow them to set.

Some flue-dust will react so strongly that a large amount of ore or coke-breeze may be added to the briquettes; in these cases the flue-dust acts as a binder.

The Schumacher process requires an inexpensive plant and the cost of manufacturing is low. It is extensively used abroad and has replaced some of the other methods. The briquettes of all agglomerated materials have given most satisfactory results abroad and highest returns and values to the blast-furnace operators.

Discussion.

Dr. F. W. C. Schniewind:—Mr. Vogel speaks of briquetting the flue-dust by means of lime. I learned recently in Europe of a process employed with considerable success at one of the blast-furnaces, where blast-furnace cinder is used with lime. The lime and cinder are mixed with the flue-dust, and exposed to superheated steam, which converts the plaster from the cinder into cement. Briquettes are then formed in the usual way.

Mr. Vogel:—The process referred to is the "Scoria process," which has not been in use for some time past. For that reason, I did not mention it.

Prof. Arthur L. Walker:—I would ask the commercial name for magnesium chloride, and where it can be obtained?

Mr. Vogel:—I mentioned magnesium chloride, because it has been used abroad to a large extent. In Germany it is obtained as a by-product in the manufacture of potash-salts; in the United States we have been using chloride of lime, which is cheaper.

Otto Sussman:—What is the cost of this process?

Mr. Vogel:—The cost is exceedingly low. I can give you the figures from abroad, but not for the United States, because the system has not yet been used here commercially to any considerable extent. In the experimental plant, the cost is somewhat high. In Germany or Belgium the cost of the process is about 1.60 marks per metric ton; at some plants it is 2 marks, so we may estimate it as from 40 to 50 cents. In the United States, our present experience is, that it will cost from 20 to 30 cents per ton. The operating-expenses are very low, because of the simplicity of the process.

ARTHUR S. DWIGHT:—What basis is there for assuming that the chloride of lime or the magnesium chloride has a catalytic action, and, if so, what is the action?

MR. VOGEL:—We consider magnesium chloride to be a catalytic agent, because it persists after causing the chemical reaction to take place, which follows its addition to the oxides; in fact, it can be extracted from the hardened briquette by means of hot water, and is often found as a white efflorescence covering the surface of the briquette.

MR. DWIGHT:—The paper says that the briquettes become hot immediately after pressing. Is there any explanation why that occurs?

MR. VOGEL:—There is a very strong chemical action—in fact, there are several different actions taking place. One, a cementation between silica, lime, and alumina; another, the reoxidation of the lower iron oxides, and still another, the hydration of oxides. If hydration alone took place, the briquettes would disintegrate in the furnace, but Schumacher briquettes will not disintegrate until they reach the fusion-zone of the blast-furnace.

MR. DWIGHT:—Does not the heating action take place almost instantaneously, the moment the briquette is compressed? I understand from the paper that such is the case.

MR. VOGEL:—Yes, when you take hot flue-dust, but not when you take cold flue-dust. In the latter case the reaction starts a quarter or a half hour after the briquette has been pressed.

MR. DWIGHT:—I drew my conclusion from Professor Richards's paper also. Possibly it would be well to leave this point for future discussion.

B. G. KLUGH, Birdsboro, Pa. (communication to the Secretary *):—In Mr. Vogel's description of the Dwight & Lloyd process, he makes the following statement: "The resultant sintered material is not homogeneous, and, while a large por-

---

* Received May 7, 1912.

tion of it is of cellular structure, it is glazed on the surface, which makes it quite difficult to reduce in the blast-furnace." This statement is so completely at variance with the facts that it is necessary to restate the properties possessed by Dwight & Lloyd sinter.

All sintering-, agglomerating-, and briquetting-processes treat finely-divided materials which are readily mixed to any required degree of homogeneity by various well-known mixing-mechanisms. Any lack of homogeneity in the finished product will be due to some inherent feature in the agglomerating-process which tends to destroy the uniform distribution of particles in the raw mixture. In the Heberlein process the heavy pressure of the upward air-blast keeps the particles of the charge at the upper surface in motion and also disturbs the particles surrounding every blow-hole and crater formed in the charge. As a result of this action there is a re-arrangement of particles in portions of the charge, and a corresponding lack of homogeneity in the finished product. In the Schumacher process or in any briquetting-process the extent to which the particles of the homogeneous raw mix are re-arranged depends upon the pressure used in forming the briquettes. With great briquetting-pressures, and with wide differences in shape and size of constituent particles in the material, there is a considerable re-arrangement of particles during the briquetting-operation, and as a result some lack of homogeneity in the finished product. In the Dwight & Lloyd process the thoroughly-mixed charge is placed on the grates and sintered under conditions that maintain absolute quiescence of the particles with relation to each other, and absolute homogeneity is therefore one of the inherent properties of the finished product.

The Dwight & Lloyd sinter is a product of incipient fusion. If we take mill-cinder as an example of a product of complete fusion, and rotary-kiln nodules and Heberlein agglomerates as examples of products resulting from an intermediate degree of fusion, then the Dwight & Lloyd sinter represents the product obtained from the least degree of fusion that effectively binds the particles together. During the sintering-operation, wherever a particle of carbon reacts with a particle of iron oxide, there is formed a microscopic gas-bubble which in escaping through the semi-fused but plastic sinter forms a capillary pore.

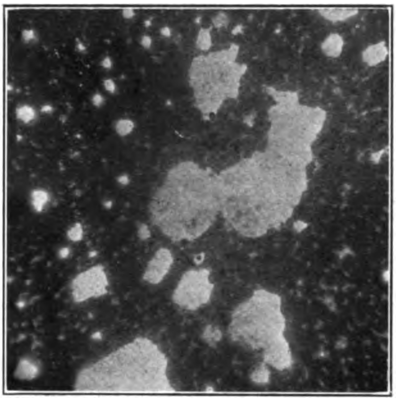


Fig. 1.—Dwight & Lloyd Sinter from Flue-Dust and Magnetite. Magnified 40 Diameters.

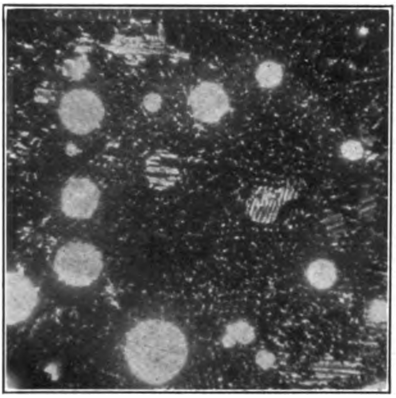


Fig. 2.—Dwight & Lloyd Sinter from Flue-Dust and Pyrites Cinder. Magnified 40 Diameters.

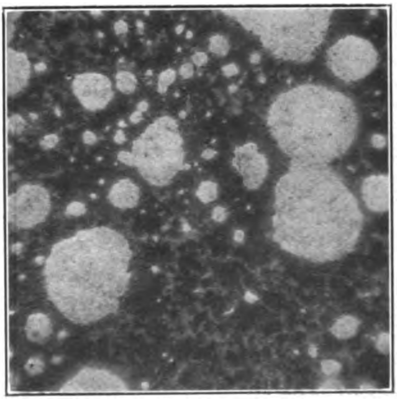


Fig. 3.—Dwight & Lloyd Sinter from Mayville Ore. Magnified 40 Diameters.

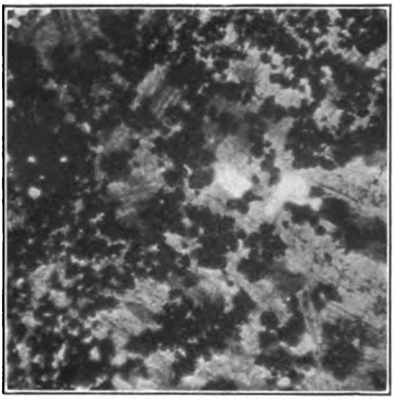


FIG. 4.—HEBERLEIN AGGLOMERATE FROM PYRITES CINDER. MAGNIFIED 40 DIAMETERS.

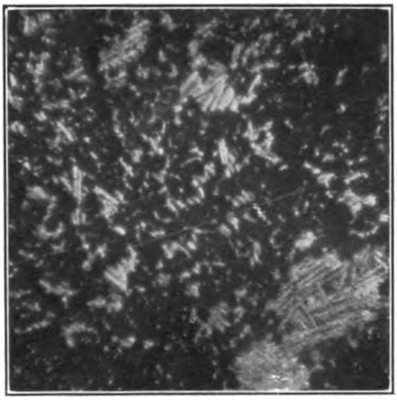


FIG. 5.—SAGMANEIRA NODULES MAGNIFIED 40 DIAMETERS.

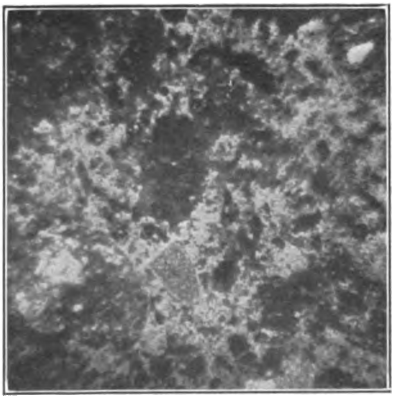


FIG. 6.—AMERICAN SINTERING CO.'S FLUE-DUST NODULES. MAGNIFIED 40 DIAMETERS.

The progressive union of these minute gas-bubbles into larger and larger units produces a series of cells, canals, and pores all intercommunicating, and of all sizes from that of a pin-point under 40 diameters magnification up to 0.5 in. or more in actual diameter.

The typical structure of the Dwight & Lloyd sinter is similar to that of a very porous sponge. The cell walls of the larger pores in the sinter are very thin, but are nevertheless highly porous, due to the presence of many microscopic pores, the number of which is roughly equal to the number of reacting particles of carbon in the sintering-mixture. The great reducibility of this sinter which has been demonstrated wherever it has been used, is undoubtedly due to its remarkable intercommunicating system of pores and cells, as a result of which all of the cell-walls are in effect highly pervious diaphragms. It is thus evident that even if Mr. Vogel's statement that the surfaces of the sinter are glazed, be true, this condition would not affect the reducibility of the sinter since the glazed surface would be perforated at innumerable points by microscopic pores. It hardly seems possible, however, that Mr. Vogel could have used "glazed" in the sense in which it is ordinarily used. In the ceramic and petrographic arts a "glaze" is understood as a covering of glass. Glass is a non-crystalline product of fusion. In the Dwight & Lloyd sinter the formation of glass would require a degree of fusion and consequent fluidity that would entirely obliterate the innumerable microscopic pores which are typical of the structure.

The micro-photographic sections, Figs. 1, 2, and 3, show the Dwight & Lloyd sinter magnified 40 diameters. The phenomenal porosity is plainly shown, together with the great preponderance of dark opaque iron oxide, and the practical absence of the lighter colored silicates, either in the form of quickly-cooled glass or slowly-cooled crystals. The mere presence of so many capillary pores under high magnification proves conclusively that fusion did not extend beyond the stage of incipiency. Fig. 4, a Heberlein agglomerate made from pyrites cinder, and Figs. 5 and 6, rotary-kiln nodules (all of 40 diameters magnification), show the absence of the typical cell structure found in the Dwight & Lloyd sinter, and a great preponderance of fused silicates both in crystalline and in glass form.

All three of these figures show a marked resemblance to the puddle-cinder of Fig. 3 in my paper presented at the New York meeting, February, 1912.[1] The presence of such a large percentage of light colored silicates, with a well-developed crystalline structure, conclusively proves that Heberlein agglomerates and rotary-kiln nodules, in common with puddle-cinder, have passed through a stage of almost complete fusion. That material possessing these characteristics is not readily reducible is demonstrated by the fact that the use of more than 15 per cent. of Heberlein agglomerates in a blast-furnace charge gives a scouring slag.

Briquettes have the type of porosity which is exhibited by water absorption and retention, caused exclusively by capillary action. Briquettes lack the intercommunicating system of cells and pores found in the Dwight & Lloyd sinter, and which are needed for the access of gas to the inner structure. The ineffectiveness of the pores in briquettes can be better appreciated by considering what an enormous pressure would be needed on one side of a briquette to produce an actual flow of gas through the structure. The porosity of a briquette is therefore of slight value in the blast-furnace, and in the stock-pile such porosity is an undesirable property, because water absorption, followed by freezing, entirely destroys the structure.

Wholly aside from any evidence here adduced, the Dwight & Lloyd sinter has been proven by actual use to be both homogeneous and very reducible. It has likewise been demonstrated that when 20 per cent. or more is used in a blast-furnace charge no scouring tendencies develop in the slag.

---

[1] See page 511 of this *Bulletin* (No. 65, May, 1912).

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Schumacher Briquetting Process.

BY JOSEPH W. RICHARDS, SOUTH BETHLEHEM, PA.

(New York Meeting, February, 1912.)

THIS method of briquetting flue-dust, or flue-dust mixed with fine ores, or, in a few exceptional cases, coke-dust, has come into large commercial use in Europe, and a small plant is already in operation in the United States. It promises to become of such great importance to the iron industry of the United States that the following description will certainly interest the majority of our pig-iron producers.

Discovered in 1908, the process rests upon the observation of Dr. Schumacher that blast-furnace flue-dust, while possessing of itself no binding or cementing properties, acquires strong cementing properties if mixed with a very small amount of certain salt solutions, the amount of which is so small that the resulting cementation appears to be rather by catalytic action of the salts added than by the mass-action of such chemicals. To be more specific, fresh blast-furnace flue-dust mixed with from 5 to 10 per cent. of its weight of magnesium chloride or calcium chloride solution—that is to say, with from 0.25 to 2 per cent. of its weight of magnesium chloride or calcium chloride—acquires the property of setting within a short time, from 15 to 60 min., and forming a hard cemented briquette. Alkaline solutions appear to have no action such as described, and they even interfere, if present, with the action of the magnesium and calcium solutions.

When treated in this way the flue-dust briquette sets very hard, apparently from pure excess of cementing- and setting-power. It is, therefore, possible to mix with the flue-dust a considerable proportion of inert ore or like material, which has no setting-power by this process, and thus to make a compound briquette containing large quantities of ore mixed with flue-dust, but in which the flue-dust may be regarded as the cement or binding-material. A particularly strongly cementing flue-

dust will carry as much as three times its weight of fine ore or the like, and yet produce a satisfactorily strong briquette.

The Cambria Steel Co. has installed at Johnstown, Pa., a small plant consisting of two presses, with a combined capacity of 250 tons of briquettes per day. One of the presses is of the mechanical type, with hydraulic safety-regulator; the other is a Ronay hydraulic press. The first makes briquettes the size of an ordinary fire-brick; the latter makes briquettes cylindrical in shape, 8 in. high and 8 in. in diameter, using considerably higher pressures than the former.

Fig. 1 is a view of a Brück-Kretschle press for the Schumacher process, installed at the works of the Société Cockerill, at Seraing, Belgium, which is similar to the one at Johnstown, and Fig. 2 shows the plant complete, from hoppers and mixer to discharge-belt.

As seen in operation early this month, the warm flue-dust from the dust-catchers was stored in one hopper, while fine Mahoning ore, containing from 10 to 12 per cent. of moisture, and quite cold, was stored in another hopper. A rotating feeding-device formed a stream of these materials, passing into the mixing-trough with ordinary spiral, into which at the same time was run a 30-per cent. solution of calcium chloride, the flow of which was regulated by a hand-valve. The trough fed the mixture directly into the hopper of the press. The flue-dust was warm, approximately at 90° C.; the ore was ice-cold; the solution was cold. The mixture fed to the press was just warm to the touch; the bricks going from the press were decidedly hot and steaming, and when loaded into the car they were quite hot to the touch and steamed vigorously.

This heating of the mixture as soon as compressed into the briquette is a characteristic of the process, and is an index of the rapid chemical reaction taking place which results in the cementing of the material.

The pressures used on the two presses seen were 5,500 lb. per square inch on the Brück-Kretschle press and 12,500 lb. per square inch on the Ronay press. The first press consumed 35 h-p., with an output of 7 tons per hour; the second press, 25 h-p., with an output of 4 tons per hour.

The flue-dust carries from 18 to 20 per cent. of coke, which is all carried into the mixture, said mixture being 70 of ore to

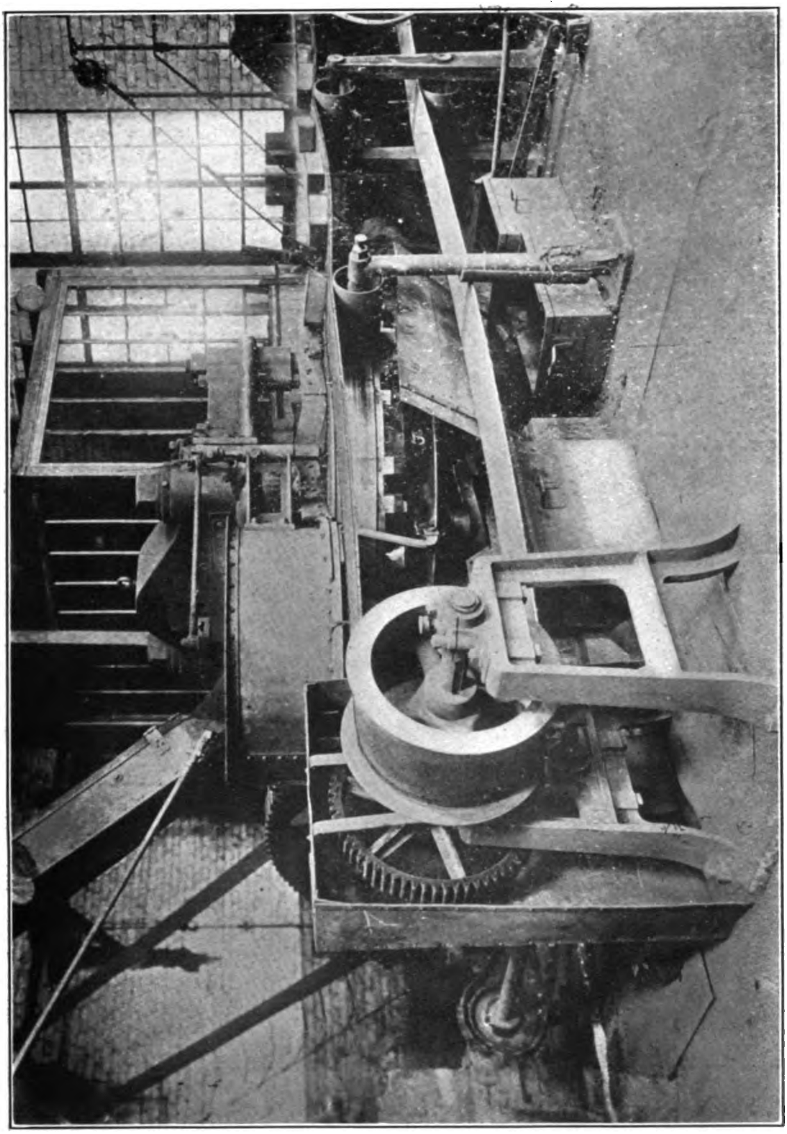


FIG. 1.—THE BRÜCK-KRETSCHLE MECHANICAL PRESS.

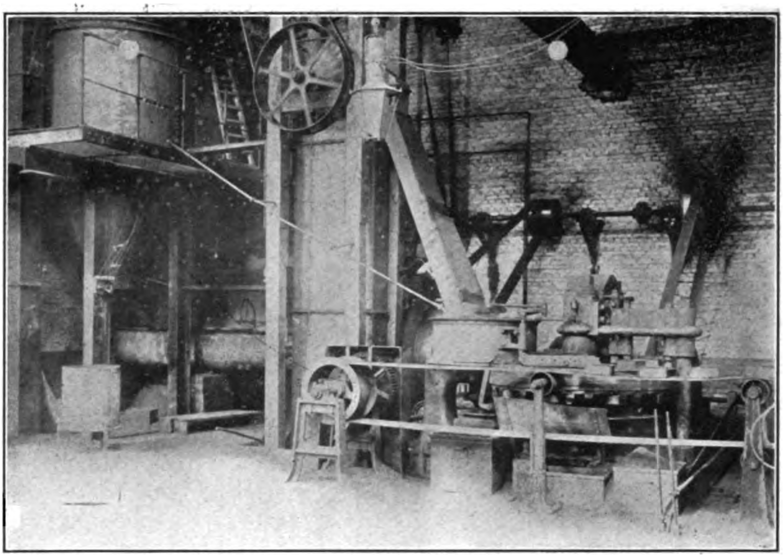


FIG. 2.—VIEW OF COMPLETE SCHUMACHER BRIQUETTING-PLANT.

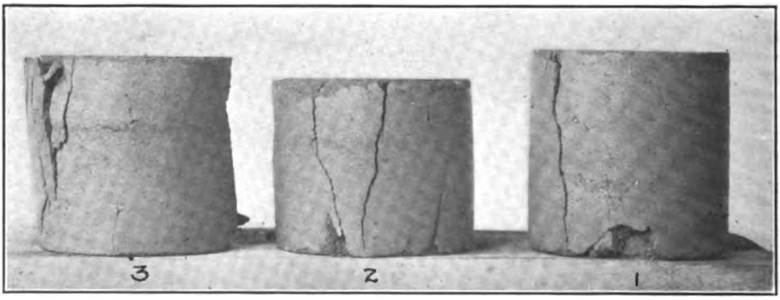


FIG. 3.—SCHUMACHER BRIQUETTES OF 70 ORE AND 30 FLUE-DUST, AFTER COMPRESSION-TEST.

30 of flue-dust. There is from 5.5 to 6 per cent. of coke in a finished briquette. The saving of this coke, 20 per cent. in weight of the flue-dust used, represents sufficient value to pay for the entire cost of the briquetting of the dust. Undoubtedly the coke thus inclosed in the briquette acts on the ore in the furnaces, and reduces it with at least as great an efficiency as the "green" coke put into the furnace. Therefore, if the furnace has sufficient smelting-power, other things being equal, this coke of the briquette may be estimated as saving at least an equal weight of coke to the furnace.

As to physical properties, a briquette made of flue-dust, tested by me, absorbed 11.5 per cent. of its weight of water, representing 27 per cent. of voids, a very satisfactory porosity.

Briquettes one day old, hard dried, tested for compressive strength by me, gave a minimum of 445 lb. per sq. in (31.8 kg. per sq. cm.). Photographs of three briquettes thus tested are shown in Fig. 3.

Several hundred tons of these briquettes were already in the ordinary furnace-bins, ready for use in the furnaces, and appeared to have stood transportation to that point and dropping from 10 to 20 ft., and also subsequent action of ice and snow for several weeks, without deterioration; only a few were broken, and but little dust was made.

The operation of producing briquettes in this manner, from flue-dust and fine ores, appears to have attained the maximum of simplicity, the operation consisting merely of mixing with solution and pressing into shape. Estimates of probable cost, if the operation were carried out upon a scale such as would suit a large blast-furnace plant, yielded as the outside figure 30 cents per ton, inclusive of depreciation, repairs, and interest on plant.

The inventor of this process has certainly made a great advance in the art of briquetting these difficult materials at a minimum cost and with maximum simplicity of plant. It is not difficult to predict a very large application of this process in the United States, as soon as the behavior of the briquettes in the blast-furnace has been proved. The very satisfactory running of similar briquettes in European blast-furnaces appears to leave no doubt upon this phase of the question also.

Theory of the Process.

Laboratory-experiments were made upon pure materials representing the constituents of flue-dust, with 0.5 per cent. of calcium chloride, with the following results:

Ground silica, after standing in air: Caked slightly under pressure with water alone; no perceptible difference with the chloride solution.

Ground silica, freshly burned: Same result.

Fine alumina, after standing in air: Same result.

Fine alumina, freshly burned: Same result.

Volatilized silica: Same result.

Coke-dust: Same result.

Pure ferric oxide, ignited at redness: With water alone, and pressed, very feebly coherent; with the calcium chloride solution, set hard and firm, and harder the greater the pressure.

Since the latter compound was chemically pure, we must find an explanation from the interaction of Fe_2O_3, $CaCl_2$ and H_2O, facilitated by pressure. The bottle of calcium chloride solution used showed a deposit of calcium hydrate on standing, caused by the well-known phenomenon of hydrolysis, and the solution became slightly acid. The reaction is

$$CaCl_2 + 2H_2O = Ca(OH)_2 + 2HCl.$$

This led us to suppose that the acid thus tending to form would immediately act on the iron oxide, forming ferric chloride, the reaction being:

$$Fe_2O_3 + 6HCl = 2FeCl_3 + 3H_2O.$$

But iron salts are precipitated by milk of lime (calcium hydrate), a well-known reaction extensively used in metallurgy and chemistry. It seems fair to suppose, then, that the ferric chloride will react with the calcium hydrate, the reaction being:

$$2FeCl_3 + 3Ca(OH)_2 = 2Fe(OH)_3 + 3CaCl_2.$$

This completes the cycle, giving back the calcium chloride with which we started, the net result being simply the conversion of Fe_2O_3 into precipitated $Fe(OH)_3$. The latter, being precipitated at the points of contact, where, under pressure,

all these reactions are taking place, forms the bonding material cementing the grains together.

The heat of hydration of Fe_2O_3 is not high, but it is positive, and would theoretically heat a lump of pure Fe_2O_3 about 80° C. This may, therefore, well be the source of the warming-up of the briquettes. It is not unlikely that the $CaCl_2$ present also ultimately sets as $CaCl_2.6H_2O$ crystals, still further strengthening the bonding action.

It has been objected to the above explanation that a briquette thus bonded would not stand heat, but would fall to powder again on being dehydrated. This did not appear probable, from a consideration of the characteristic shrinking together and hardening or fritting of $Fe(OH)_3$ on being ignited (all chemists know how this precipitate burns to a hard, horn-like mass); but, as Deville used to say, "*ce n'est pas nécessaire de théoriser si on peut faire l'expérience*," and accordingly the briquette of pure iron oxide with the Schumacher solution was heated to redness: it stayed in a single lump and became harder than before.

It appears that the explanation of Dr. Schumacher, that the solution "acts as a catalytic agent to develop the latent setting-power of the flue-dust," is not very wide of the mark, and fits the facts, if we assume the reaction to proceed by the circular procedure (*Kreis Process*) above set forth, about as well as the term "catalytic" fits many chemical phenomena to which it is usually applied.

Discussion.

Prof. J. W. Richards (in reply to several questions): The cut representing some of the round briquettes which were under test shows that, at the breaking-stresses, they break into lumps, and do not disintegrate into powder.

The process is simplicity itself. I have followed the different processes for sintering iron-ores and flue-dust, am interested in all of them and wish them all success; but this process appealed to me strongly by its simplicity. It is in line with a method which I once tried to work out myself, but which never came to anything, namely, the agglomeration of fine iron-ores by means of Portland cement. As small an amount as 5 or 6 per cent. of Portland cement will enable fine ore to agglomerate

and set into a briquette, but when I came to estimate the cost, I found it was a little too high.

The Schumacher process, curiously enough, does not work well on iron-ore, but flue-dust thus treated does harden and give a strong briquette. In my attempts to find a reason for this difference, it has occurred to me that possibly the particles of flue-dust had been coated over with some sublimed silica, which might be an agent in the setting. But I found by experiment that neither sublimed silica, nor ordinary silica, nor ordinary alumina, would briquette. Chemically pure iron oxide briquetted quite hard; but the application of pressure is a necessary part of the operation. If simply moistened with the solution and allowed to stand it does not set hard, but the more pressure applied to it the harder it sets. Evidently the flue-dust particles must be pressed very close together in order to get the small proportion of active material wet, so that the particles shall act at their points of contact; for it is evident that only at the points of contact does the cementing action take place.

The reactions are facilitated by considerable pressure, bringing the acting particles close together, and may go on with considerable rapidity, and thus a small amount of calcium chloride produces a considerable amount of bonding material at the points of contact of the particles, the bonding material being principally ferric hydrate.

Some think that an iron hydrate will naturally go to pieces when heated, but it does not if you start with lumps; and we know that these briquettes do not go to pieces when heated. It is true that we have other things besides pure iron oxide in flue-dust. There may be deposited or sublimed silica on the surface; and there are other materials mixed in with it, and these may combine with the iron hydrate to form a little different compound from simply pure ferric hydrate.

As to the success of this process abroad, I understand that there are 18 plants now in operation in Europe, and there has been no question as to the briquettes behaving properly in the blast-furnace. The briquettes are this week being worked in the blast-furnace at the Cambria Iron Works, and have proved their suitability.

A. S. Dwight: The increase in temperature shown by the fresh briquettes seems to indicate some interesting reaction, which, if understood, might throw light on the chemistry of the process. In the reactions which Professor Richards has written on the blackboard I should expect, without having actually figured it, that the thermal result would equal zero.

Professor Richards: The sum total of the reactions is that the iron oxide becomes hydrated oxide, and the heat of hydration of the iron becomes the source of the heating of the briquettes. As the briquettes come from the press at Johnstown, they steam very vigorously. Part of the steaming was due to the briquettes being warm when made, and coming in contact with the cool atmosphere outside; but it is a fact that briquettes made of cold flue-dust, with calcium chloride, warm up afterwards on standing in the air.

The press does mechanical work upon the briquettes, which I calculated roughly could raise the temperature of the briquettes 10° C., but there is undoubtedly a heating effect due to chemical action, which shows itself after the making of the briquettes, while they are standing in the cars.

A. S. Dwight:—Returning to the matter of the increase in temperature of the fresh briquettes, I call attention to a phenomenon I have frequently observed in lead-smelting practice, which may perhaps throw some light on this question.

About 20 years ago briquetting began to be adopted on a large scale by the lead-smelters for handling fines of all kinds, such as roasted ores, flue-dust, and other by-products. This custom has now been largely abandoned on account of the high cost and generally unsatisfactory metallurgical results obtained with the briquettes. The practice was to mix the material thoroughly with from 5 to 10 per cent. of milk of lime, as a binder, and press it into briquettes, using any of the several forms of apparatus developed for the purpose, the most successful of which was the "White" mineral-press. The briquettes as turned out were delivered automatically to a traveling-belt, from which they were picked by hand, stacked, and air-dried until they would stand handling to the furnaces. When flue-dust was present in the mixture, there was always observable

in the neighborhood of the mixer and press an odor of ammonia, sometimes so strong as to irritate the eyes of the attendants. At the same time the briquettes exhibited a perceptible rise of temperature, similar to that described by Professor Richards as taking place in the Schumacher process. Just what the reaction may have been which caused the evolution of the ammonia, I would not care to say definitely, as I never seriously investigated the question. The flue-dust from a lead blast-furnace is likely to carry from 1 to 5, probably averaging 3, per cent. of carbon as fine coke-dust, besides iron oxide, silica, limestone, lead oxide, sulphur, etc. With coke-dust, iron oxides, moisture, and active lime-reagents present in both cases, there certainly seems to be a sufficient similarity to lead us to suspect that one reaction might throw some light on the other. I simply suggest this thought as a possible help in the inquiry to explain what actually takes place in the Schumacher process—a problem which at the present time seems to me not satisfactorily solved.

Prof. Henry M. Howe: The explanation which Professor Richards has given seems to be reasonable, but I am not sure that it would not be more convincing if we left out some of the reactions. If we start with calcium chloride and iron-ore, it is reasonable to suppose that we may end with a large amount of basic iron chloride. We know how basic iron chloride (as, for instance, in a rust-joint) makes a cement—that is what the stuff really is. We can get such a cement with a little sal ammoniac and iron-filings—according to my recollection, a sticky sort of cement containing basic iron chloride. From a small amount of chlorine we get a relatively large quantity of this sticky basic iron chloride. The reason I think the reaction is likely to occur in that way, rather than by the exact steps mentioned by Professor Richards, is that the first reaction looks as if it would be an endothermic reaction.

As between iron-ore and flue-dust, is not the reason why the former will not agglomerate, or cement, as the latter will, that iron-ore is very much coarser than flue-dust? As I understand it, that which cements in a roadway, for instance, is the very finely powdered trap-rock, and if you have rock which is not broken up into a finely-powdered form, you will not get any

cementing action in the road. That may be one of the conditions in this case.

As to the heat given off, the amount is not stated. If it is considerable, it will have to be made up for, in the furnace. For it implies a loss of energy, which must be replaced in the furnace by a correspondingly greater evolution of heat. I fancy, however, that this item is not important.

As to the mechanical differences in these briquetting processes, it is very easy to say that the mechanical conditions are all right or all wrong, but so long as these assertions are merely speculative, they ought not to carry great weight. We must look to actual practice. As I understand the author of the paper, he has investigated this matter and is convinced that there is a certain reduction in fuel-consumption through a given process. A piece of actual evidence to that effect is worth all the speculation that can be had as to whether the result might be one way or the other.

Dr. F. W. C. Schniewind: Perhaps Professor Richards could throw some light on this matter by stating what he knows about the thermo-chemistry of the reaction that begins with ferric oxide and ends with ferric hydroxide. How many heat-units are involved in the conversion of the oxide to the hydroxide? Furthermore, has Professor Richards made any investigation as to whether any of the other ingredients of the flue-dust alone, with calcium chloride or magnesium chloride, will show heating under compression?

Professor Richards: I have tried the other ingredients of the flue-dust, such as silica and alumina, in the laboratory. When moistened with the solution they became cold, and under pressure (on a small scale) they did not show any perceptible rise in temperature. With regard to the operation on a larger scale, the ore of Johnstown was quite cold, the flue-dust was warm, but not hot, and the briquettes coming out of the press seemed to the touch much hotter than they should be from the admixture of the two materials—30 parts of flue-dust and 70 of ore. I believe that when the operation is carried out on a large scale, there is always a warming-up of the briquettes, which is greater, the warmer the mixture before being pressed.

As to the heat of hydration of iron oxide, I have figured that it would raise the temperature of the briquettes about 80° C., if all the iron oxide present were hydrated at once.

A. H. Cowles: I can appreciate Dr. Richards's evolution of his hydrolysis theory, from the fact that if you start with aluminum chloride solution, it does hydrolyze, and magnesium chloride also tends to separate out chlorine quite easily, but calcium chloride less than either one of them. Dr. Richards, being so familiar with the chemistry of aluminum, I can see easily the way that theory would arise in his mind, as an explanation of the so-called "catalytic effect" of the salt.

Professor Richards: In answer to Mr. Dwight's question as to why he should have obtained ammonia by wetting fume from lead-furnaces, it is possibly from nitrides of some of the materials which are blown out of the furnace, particularly aluminum nitride. There are processes for making aluminum nitride by heating alumina with carbon in a furnace at the proper temperature and blowing nitrogen over it, and that nitride, when moistened afterwards, would give rise to ammonia.

A. S. Dwight: Would that be likely to occur in the case of lead-furnaces, in which the temperatures necessarily have to be kept much lower than they would be kept in an iron blast-furnace, and the flue-dust of which undoubtedly comes from near the upper zones of the furnace, where the temperature is so low that you can hold your hand there without discomfort? The flue-dust comes principally from the upper 3 or 4 ft. of the lead blast-furnace.

Professor Richards: The lead-fume does not all start from the top of the furnace; part of it starts from the lower portion; and I suggest the possibility of nitrides coming from that portion. It takes only about 1,200° C. to begin the production of aluminum nitride from a mixture of alumina and carbon, through which is passed a gas containing nitrogen and carbon monoxide.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Briquetting of Iron-Ores.

BY N. V. HANSELL, NEW YORK, N. Y.

I. Introduction.

The last few years have shown an increasing interest in the subject of beneficiating iron-ores in all iron-producing countries. In the United States, this movement has been slower than in certain parts of Europe, for the obvious reason that the abundance and relative cheapness of the Lake Superior iron-ores has hindered the development of enterprises for the preparation of low-grade ores. Gradually, however, conditions have changed. The world's consumption of iron is increasing enormously. Being in 1900 about 40,000,000 tons, in 1910 it was already 60,000000; and there is no reason to doubt that for the near future the increase in iron-consumption will continue at the same rapid rate, especially with the development of China, certain parts of Africa, and other regions which have hardly been touched as yet by modern industrialism. It is, therefore, not surprising that apprehension is felt that the known available iron-ore resources of the world are gradually being depleted. Signs of this feeling are the recent investigation, under the direction of the U. S. Geological Survey, of the iron-ore resources of the United States, and the estimate presented to the last International Geological Congress, at Stockholm, Sweden, of the iron-ore resources of the world. These investigations have emphasized the fact that the known high-grade ore-deposits are limited in extent, and will, at a not distant future, be exhausted, compelling the iron industry to depend for raw material on the enormous deposits of low-grade ores which are distributed over almost all the world. The discovery of new deposits of high-grade ore, in countries not yet thoroughly explored, will not materially change this prospect. Of course, the part which such new deposits will play in the future cannot be forecast. The difficulty and cost of transportation will probably exclude many of them from use at the present centers of the iron industry.

In view of these facts, it is no wonder that great interest is displayed in the subject of making useful such ores as have heretofore been discarded because, in their natural state, they are not suitable for blast-furnace operations. First among these are ores the low iron-content of which precludes their direct use in the furnace, so that they have to be crushed and concentrated, giving as result a finely-granulated product, high in iron; and, in the second place, there are the ores which, although sufficiently high in iron, are rendered undesirable by either their physical or their chemical character.

Modern blast-furnaces, with their high stacks and heavy blast-pressure, make it difficult to include in the burden too high a percentage of dusty or finely-granulated ore, such, for instance, as some of the fine Mesaba ores. There are furnaces where conditions compel the management to use 60 or 70 per cent. of such ores; indeed, I am told of furnaces using 100 per cent.; but in such a case the manager will voluntarily tell his woeful tale of the unavoidable losses in the form of flue-dust, of scaffolding in the furnace, and of frequent explosions. The fine ore, descending more quickly than the rest of the charge, reaches the smelting-zone only partly reduced. This causes disturbance in the furnace-operations, with frequent casts of off-iron. Therefore, if it can be economically done, it is highly desirable to convert to a lump form all such fine ores, whether they have been obtained in the form of fine concentrates in the separation of low-grade iron-ores, or mined as natural soft and fine ores. A high sulphur-content in the fine ore is often an additional reason for its preparation by agglomeration, since the sulphur-content is usually reduced by such a preparation, making the ore doubly attractive to blast-furnace managers.

In this country, however, the real impetus to the development of processes for agglomerating fine iron-ores, has been, not the desire to promote the utilization of such natural fine ores, but rather the necessity of finding some way of preparing for blast-furnace use such waste products as flue-dust, pyrites-residues, etc. The most important of these is the flue-dust, of which it is reported that between 2,000,000 and 3,000,000 tons are annually produced in the United States. A part of this is recharged into the furnace after a thorough wetting, intended to prevent its being directly blown out again. That this practice is not satis-

factory is indicated by the vast and growing piles of this material around furnace-plants in the Middle West, where a high percentage of soft ores is used in the burden. This waste is especially great when a furnace has been long in blast, and begins to be somewhat rough in the lining. The flue-dust contains from 35 to 45 per cent. of metallic iron, with from 5 to 20 per cent. of coke. Assuming the value of the original ore at the furnace as, say, 7 cents per unit of iron, the intrinsic value of this so-called waste material is probably about $3 per ton. Low iron-prices, and the consequent necessity of greater economy on the part of the blast-furnace manager, have brought to light this leak, through which often as much as 10 per cent. of the ore charged goes for naught.

Of the pyrites-cinder, about half a million tons are produced annually. On account of its usual pulverous condition and high sulphur-content, it was formerly thrown away, or perhaps, at the best, used for reclaiming land or building roads, although it frequently contained as much as 55 or 60 per cent. of iron.

The modern methods of utilizing for the iron industry, through agglomeration, these waste products or these low-grade ores, which in their natural state are unsuitable for blast-furnace operation, certainly form a not unimportant element in the present movement for the conservation of natural resources.

II. Methods of Agglomeration.

The many methods proposed or now employed for the agglomeration of fine iron-ores can properly be divided according to radical differences in the processes themselves, and also to some extent in the nature of the products, into the following three classes: First, nodulizing in revolving kilns; second, blast-roasting; and third, briquetting, with or without binding material, usually followed by a heating of the briquettes.

1. *Nodulizing.*

This method gained early prominence in the United States, where a number of plants are now in operation; the pioneer plant at Hackensack Meadows, N. J., treating pyrites-cinder; others, like those at Lebanon, Pa., Benson, N. Y., and Standish,

N. Y., treating ore-concentrates; and still others, like the Hubbard plant in Ohio, treating flue-dust. The most modern establishment of the kind is the one at Felton, Cuba, described by J. E. Little.[1]

In Germany, similar methods are in use for the roasting and sintering of carbonates; and in Canada there is a plant of four kilns now under erection for the same purpose. For such ores as decrepitate and shrink considerably in roasting, the method is specially valuable. The product is, however, seldom uniform. Occasionally, the nodules are vitrified and very dense; occasionally they are loose and brittle, producing much dust in handling. Difficulties in keeping the kilns free from scaffolds or rings, necessitating shut-downs every 8 or 10 days, tend to make the cost of production higher than a first investigation of the merits of the process seems to indicate.

2. *Blast-Roasting.*

It is not necessary to dwell at any length on this process, which has been described by James Gayley,[2] whose paper was presented orally by Arthur S. Dwight at the Wilkes-Barre meeting of the Institute, June, 1911, and by B. G. Klugh in a paper presented at this meeting. The product is spongy, and forms undoubtedly an excellent raw material for the blast-furnace.

3. *Briquetting.*

At a meeting of the Iron and Steel Institute in 1910, Chevalier C. De Schwarz, of Liège, read a paper on the briquetting of iron-ores.[3] In this he gave as conditions for successful briquetting:

"1. The iron ore briquettes must have a certain resistance against mechanical influences. They must resist a pressure of not less than 2000 lbs. per square inch, and, when dropped from a height of 10 feet on a cast-iron plate, they must not fall into dust although they may break into pieces.

"2. They must resist heat. Heated to 900° C. they may commence to sinter, but they must not disintegrate into small fragments.

"3. They should be capable of being placed in water for a certain time without softening.

"4. They must resist the influence of steam at 150° C. without crumbling.

---

[1] *Trans.*, xlii., 152 (1912).

[2] *Trans.*, xlii., 180 (1912).

[3] *Journal of the Iron and Steel Institute*, vol. lxxxii., p. 10 (No. II., 1910).

"5. They must possess a certain amount of porosity in order to allow the carbon-monoxide in the blast-furnace to penetrate the interior of the briquette and to exercise its beneficial reducing influence."

"6. The binding medium, if any is used, should not contain noxious substances (sulphur, arsenic) to such an extent as to be injurious to the quality of the pig iron produced.

"7. The cost of producing briquettes should not exceed the difference in the prices between lump ore and fine ore."

In other words, the briquettes must be able to endure handling, transportation, and storing in the open air without too much disintegration, and to exist in the upper part of a blast furnace without crumbling into dust. In addition, they ought to be easily reducible. If a binder is used, it should be of such a nature that it adds no deleterious elements; and it ought not to lower too much the iron-content of the material.

In calculating the technical economy, by which any process must stand or fall, it must be recognized that this cannot be determined by the briquetting-cost alone. The value of the finished product and its influence on the cost of pig-iron manufacture must be taken into consideration. For the preparation of a briquette which is easily reducible with a low consumption of coke, and the use of which increases the output of the blast-furnace, one can afford to pay more.

Of the numerous proposed methods, several of which have gained commercial prominence, some are better adapted to certain classes of ore than others. This is natural, since the processes have been originated and developed at places where necessity has called for them. Mr. Schwarz in his paper describes a briquetting process used at Kertsch, Russia, and Ilsede, Germany, where the ores are of a clayey nature; adding from 6 to 8 per cent. of water to the mixture. The ore is pressed into bricks at a low pressure (from 4,000 to 5,600 lb. per sq. in.), and heated to a temperature of only 75° C. The use of higher pressure would make the briquettes too dense. Parallel cases can be cited from other places. A high sulphur-content in the ore, for instance, gives prominence to a method by which in the briquetting the ore is heated sufficiently for an effective roasting.

To describe even the main features only of the various briquetting processes that have come into commercial use in Germany, for instance, would take me too far away from the

real subject of my paper. Persons interested may be referred to G. Francke.[4] But I will mention some of the more successful methods, in order to compare them with the Gröndal method, which it is my purpose, in this paper, to describe. The various briquetting processes may be divided into those that use a binder and those that do not. This is a very practical distinction. There can be little question that a binder used to cement together the ore-grains fills the voids between them, producing a briquette of low porosity. This must have an unfavorable influence on the behavior of the briquettes in a blast-furnace. The more porous an ore or a briquette, the more easily is it reduced. This is obvious, as in the upper part of the blast-furnace the ascending gases penetrate the porous briquette, and deposit fine carbon through dissociation throughout it, which causes a direct reduction of it before it has reached a great depth in the stack. The binder also lowers the iron-content of the briquette. In most cases from 8 to 10 per cent. of binder is employed; and the smelting and slagging of this material increases the fuel-consumption.

The binders most in use seem to be of the nature of hydrosilicates, which are hardened either by exposure in air a long time or by being treated with steam under pressure. The *Deutsche Brikettierungs Gesellschaft* advocates a method of this kind, forming with the binder a silicate of lime. The *Scoria Gesellschaft*, of Dortmund, uses from 8 to 10 per cent. of basic blast-furnace slag, or a mixture of 4 per cent. of slag with 4 per cent. of CaO. The ore is ground with the binder, pressed into briquettes, and hardened in steam. The Weiss method[5] is to mix the ore with 5 or 6 per cent. of hydrated lime, form the briquettes at a pressure of 4,500 lb., and expose them to the influence of CO_2 gases, first cold and then hot, at 300 lb. pressure. The Tigler process (Duisburg-Meiderich) employs a binder consisting of from 6 to 8 per cent. of slaked lime, sometimes with an addition of 1 per cent. of blast-furnace slag. The Schumacher process for flue-dust utilizes the hydraulic properties of the flue-dust, which, like cement, contains lime, alumina, and soluble silica ready for combination.

---

[4] *Handbuch der Brikettbereitung* (Stuttgart, 1910).
[5] *Stahl und Eisen*, vol. xxxi., No. 38, p. 1539 (Sept. 22, 1911).

By the addition of a small amount of magnesium chloride, calcium chloride, or certain other salts, good briquettes can be obtained. The flue-dust ought to be used hot, direct from the dust-catchers.

Many organic binders have been tried, but few have been satisfactory. Trainer uses 4.5 per cent. of *zellpech*, which is a waste lye, resulting from the manufacture of sulphite pulp. This and similar binders coke in the upper part of the blast-furnace stack, and thus continue to hold the fine ore together until a reducing-zone in the furnace is reached. They are, however, generally too expensive to be used.

Of methods without binder, I will mention the one known under the name of Ronay. For the binder is substituted a high pressure (from 900 to 1,000 atmospheres) in hydraulic presses. This process has been more used for metal filings, etc., than for ores. The briquetting of clayey ores without a binder has already been mentioned. In reality, the clayey constituent of the ore serves as a binder.

The only process of importance that remains to be spoken of is the Gröndal, which consists in the briquetting of fine ore, etc., at a medium pressure, and the burning of the briquettes at a high temperature in a specially-constructed channel-furnace.

III. The Gröndal Process.

In 1899, when Dr. Gustav Gröndal was manager of the Pitkaranta Iron Works, in Finland, he built his first channel-furnace for the briquetting of iron-ore concentrates. Similar furnaces had been used previously for the burning of clay bricks, but for the adaptation of the process to the treatment of iron-ores and for the gradual development of a modified type of furnace suited to this special purpose the honor belongs to Dr. Gröndal. Figs. 1 and 2 are views of a pair of Gröndal furnaces, the latter showing the car loaded with briquettes. Sectional views of the furnace are presented in Fig. 3.

The first furnace at Pitkaranta was completely successful and a good deal was written about it in the contemporary technical press of Europe. It was followed by one at Bredsjö, Sweden, built in 1902. Since that time, a great number of furnaces have been built both in Europe and in this country.

At present, there are 16 plants in Sweden, with a total of about 35 furnaces and a briquetting-capacity of about 400,000 tons a year. In Norway, there are 3 large plants: Sydvaranger with 8, Salangen with 4, and Dunderland with 4 furnaces. In England 12 furnaces have been built, all treating pyrites-residues and "blue billy." Italy has 1 plant, Spain has 2; and in the United States there are 6 plants in operation or construction. In Canada the first one is being built by the Moose Mountain Co., Ltd., for the treatment of magnetite concentrates.

1. *Construction of Furnace.*

The Gröndal furnace can briefly be described as a channel-furnace, through which the ore, previously pressed into bricks, is transported on flat cars, which form a continuous movable platform. It is heated by means of gas introduced through the raised arch at a distance from the entrance-end of about two-thirds of the furnace-length. The flat cars are usually built of structural steel with fire-brick tops, and are furnished on each side with flanges dipping into sand-troughs. They are often built with overlapping ends so that when they are pushed against each other in the furnace they separate completely the upper part of the furnace, through which the gases pass, and the lower part, in which are the trucks and the wheels. The furnace-walls are built double, with an outside wall of red brick and an inside one of fire-brick; the two being separated by an air-space, which assists in lowering heat-losses by radiation, and at the same time permits the walls to move independently of each other in expanding and contracting on account of changes in temperature when the furnace is started and stopped.

For obtaining the necessary temperature, almost any kind of fuel that has sufficient calorific value can be used. In Europe, the rule has been to use producer-gas, except at some places in Sweden, where the furnaces are built at iron-works, and a mixture of blast-furnace gas and producer-gas is burnt. Blast-furnace gas alone is too diluted, and must be enriched with producer-gas to give the high temperature required for the reaction. When it is available, however, it is economical, as the coal-consumption in the gas-producer can thereby be cut almost in half. In the United States, crude oil is used at two

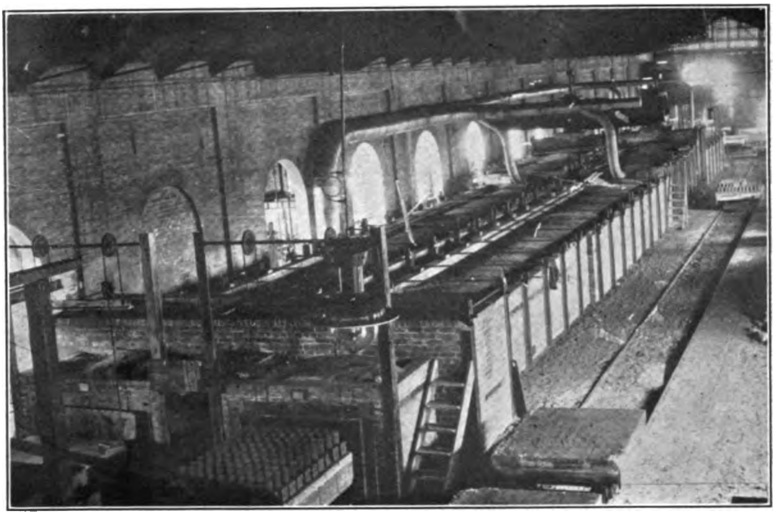


FIG. 1.—A PAIR OF GRÖNDAL BRIQUETTING-FURNACES.

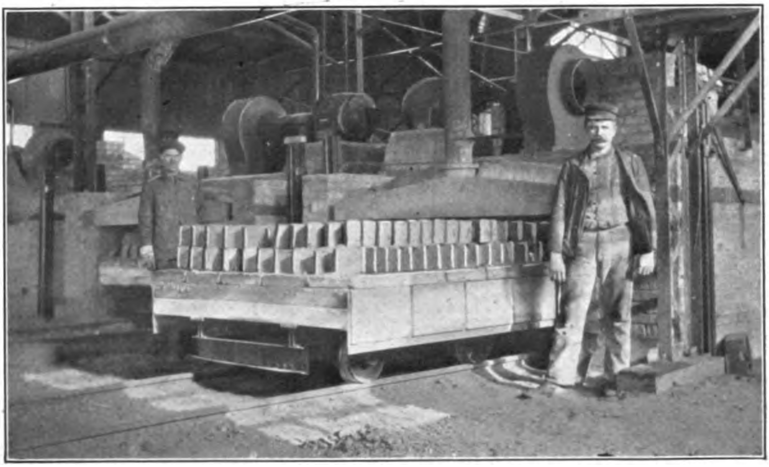


FIG. 2.—ONE END OF A GRÖNDAL FURNACE, SHOWING A CAR LOADED WITH BRIQUETTES.

plants and natural gas at two. Local conditions govern the choice of fuel.

For different fuels and for different ores the construction of the furnace must be somewhat modified, although broadly the design is governed by the same principles. In the first third of the furnace the briquettes are preheated by the escaping combustion-gases; they pass through zones of increasing heat as the cars are pushed forward. In the combustion-chamber the heat is maintained at about 2,500° F. When the briquettes have passed the combustion-chamber, they gradually pass through the cooling-chamber, into which air is blown by means of a fan; and when they leave the furnace, they are sufficiently

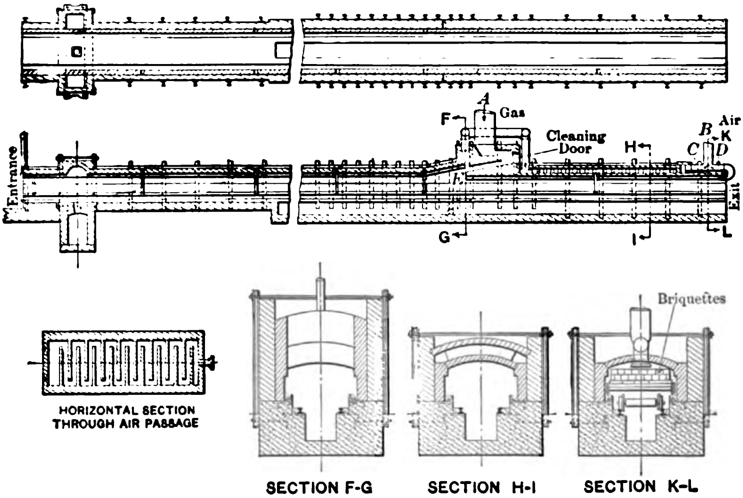


FIG. 3.—THE GRÖNDAL BRIQUETTING-FURNACE. SECTIONAL VIEWS.

cool to be loaded directly into railroad-cars. The arch over the cooling-chamber is double, and, in some installations, is made of corrugated cast-iron plates. Through the space between the double arches passes the air that is to be used directly for the combustion. On reaching the burners or the combustion-chamber it has a temperature of from 400° to 600° F. The outgoing combustion-gases generally reach the stack-flue with a temperature of from 350° to 500° F. It will be seen that the furnace is built on the regenerative principle, and that its heat-efficiency is good. The walls, as has been said, are double, and the arch is usually covered with 8 or 10 in. of sand, so that radiation-losses are low.

2. *Chemical Reactions.*

As a rule, regardless of their original composition, the briquettes are discharged as a peroxide of iron (Fe_2O_3). If the ingoing ore is a hematite, it is gradually transformed into Fe_3O_4, as the ore passes towards the combustion-chamber. In a nearly white-hot condition, it is here met by a current of highly-heated air. This gives the ideal conditions for a rapid conversion from Fe_3O_4 to Fe_2O_3. Here lies the secret of the Gröndal process. Briquettes at a temperature of 2,400° or 2,500° F. are met by air of high temperature. The oxidation is almost instantaneous,[6] and liberates an appreciable amount of heat, to the benefit of heat-conditions in the combustion-zone.

A quick oxidation of the Fe_3O_4 produces a blue, crystalline Fe_2O_3. A slow oxidation would give a reddish, earthy, amorphous product. Hence, it is necessary to maintain a high temperature in the combustion-zone. The color and condition of the discharged product tell whether the furnace is run properly. Dark blue, firm and strong briquettes indicate a right temperature; loose and reddish briquettes, a temperature too low.

When the ingoing material is a magnetite, it is probably oxidized to a certain degree on its way towards the combustion-zone. This oxidation is probably followed by a dissociation as the briquettes enter the hotter part of the furnace; but the Fe_3O_4 so formed is again oxidized to Fe_2O_3 before being cooled off and discharged. This last re-oxidation is so complete that analyses usually show more than 90 per cent. Fe_2O_3 of the total iron oxide in the briquette.

It is probably these chemical reactions which account for the agglomeration and the great strength of the briquettes. The material is not rolled together when in a plastic state, as in the nodulizing process; nor fused together, as in the blast-roasting, which gives a sintering-product usually of little strength; but in the re-oxidizing of the lower oxides of iron diminutive crystals of hematite are formed, growing out on the surface of each ore-grain in the briquette. These small crystals interlace with each other or grow together, forming a strong bond between the grains. If the ore is not crushed fine enough, or

---

[6] G. Gröndal, *Stahl und Eisen*, vol. xxxi., No. 14, p. 537 (Apr. 6, 1911).

consists of rounded pebbles, this intergrowing effect may not be obtained, and consequently the resulting briquettes will be loose and easily disintegrated. Such was the case in tests with the concentrated product from St. Lawrence magnetic sands. It was found necessary to pass a part of the iron sand through a grinding-mill in order to get some fine material to fill the voids between the larger pebbles. With pyrites-residues there has been the same experience. If strong briquettes are desired, it is futile to try to briquette cinder from lump-pyrites without first grinding it so as to pass, say, 20-mesh.

It has been mentioned that the briquettes in passing through the furnace are desulphurized. The conditions in the furnace are favorable to a complete desulphurization, namely: a high heat, a strongly oxidizing atmosphere, and a porous material consisting of finely-granulated ore-particles, permitting the gases to reach every diminutive grain. Moreover, the material stays in the hot zone for several hours, permitting a gradual oxidation of the sulphur, which escapes in the form of dioxide, with probably a small amount of trioxide. At Bayonne, cinder originally containing 2 or 3 per cent. of sulphur is discharged with about 0.03 per cent. Similar results are shown in the following table:

TABLE I.—*Chemical Results of the Gröndal Process.*

Works.	Crude Ore.			Concentrates.				Tailings.	Briquettes.		
	Iron.	Sulphur.	Phosphorus.	Iron.	Sulphur.	Phosphorus.	Recovery.	Iron.	Iron.	Sulphur.	Phosphorus.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Herrang, Sweden	40.2	1.21	0.003	67.3	0.170	0.002	92.9	6.4	65.5	0.003	0.002
Vigelsbo, Sweden	35.2	0.45	0.026	67.1	0.089	0.002	90.0	6.7	65.2	0.010	0.003
Strassa, Sweden	46.8	0.030	0.015	69.2	0.015	0.003	95.4	6.1	67.1	0.005	0.003
Lulea, Sweden [a]	58.2	0.110	1.230	71.1	0.015	0.005	95.5	12.0	69.3	0.005	0.005
Guldsmedshyttan, Sweden [a]	50.7	3.0	0.003	70.1	0.5	0.002	93.5	10.2	68.2	0.010	0.002
Flogberget, Sweden	27.3	0.31	0.003	67.4	0.040	0.008	82.7	7.1	65.3	0.007	0.008
Bredsjo, Sweden	35.0	0.15	0.010	67.2	0.050	0.004	89.5	6.9	65.1	0.020	0.004
Helsingborg (purple ore)	60.6	0.17	....	....	....	....	....	....	60.6	0.023	
Salangen, Norway	35.7	0.039	0.28	69.3	0.019	0.009	92.8	4.9			
Sydvaranger, Norway	38.0	0.066	0.030	69.0	0.026	0.006	92.8	5.5	67.0	0.006	0.006
Cwmavon, S. Wales (pyrites-residues)	64.2	2.79	0.019	....	....	....	....	....	64.2	0.035	
Tharsis S. & C. Co., (Cardiff, England)	64.8	0.31	....	....	....	....	....	....	64.6	0.054	
Cornwall, Pa. [a]	39.5	2.5	0.031	68.9	0.51	0.011	72.0	19.2	66.9	0.010	0.014
Bayonne, N. J.	60.0	2.5	....	....	....	....	....	....	62.0	0.05	
Mayville, Wis.	46.2	0.035	....	....	....	....	....	....	56.0	0.01	
Moose Mountain, Canada	36.19	0.024	0.072	65.58	0.029	0.020	89.0	7.6	63.5	0.014	0.020

[a] Crude ore contains hematite, pyrites or other non-magnetic ferro-compounds.

3. *The Briquettes.*

I will mention here the results of only a few of the many tests made to determine the suitability of Gröndal briquettes for blast-furnace and open-hearth use.

Last year a low-grade magnetite was crushed and concentrated in a large commercial test. A part of the concentrate was briquetted at Bayonne, N. J. Of the product, about 7 tons were shipped in an open bottom-dump car to Youngstown, Ohio. Here, in unloading, the briquettes were dropped upon an iron floor from a trestle 30 ft. high. A screen-test of the unloaded material showed 8.84 per cent. of the total mass passed through a 0.5 in. screen. These fines gave the following results under a sieve-test:

	Per Cent.
On 8-mesh,	69.70
On 20-mesh,	16.66
On 40-mesh,	4.55
On 60-mesh,	0.81
On 80-mesh,	0.80
On 100-mesh,	0.60 + 0.06
Through 100-mesh,	6.66 + 0.16
Total,	99.78 + 0.22

This result shows that the total amount of fines passing through 40-mesh after the briquettes had been dropped 30 ft. upon an iron floor is only 0.8 per cent.

A regular compression-test of the same briquettes showed that they would withstand a pressure of 5,221 lb. per sq. in. That in handling they form a very small amount of dust was shown by the following test. A number of briquettes were reduced in a Gates crusher, to fragments 0.25 in. and less in diameter. A sieve-test of the crushed material gave only 10 per cent. through the 100-mesh sieve, and very little on the other fine sieves.

The porosity of the briquettes—that is, the ratio of voids to the total volume—is always more than 20 per cent. This is a strong point in their favor, since it aids in making them easily reducible in the blast-furnace.

4. *The Use of the Briquettes.*

John Jermain Porter, in his paper, The Fuel-Efficiency of the Iron Blast Furnace,[7] presented at the Wilkes-Barre meeting of the Institute, June, 1911, says:

"The great desirability of having an ore which is readily reduced by carbon monoxide rather than by solid carbon, and in addition is reduced at such low temperatures that the resulting carbon dioxide has no solvent power, has been frequently pointed out. The importance of carbon-deposition in this connection does not, however, seem to be so generally appreciated. It will be recalled that this reaction, $2\ CO = CO_2 + C$, begins at about 430° and ceases entirely at 900°. That is, it takes place very near the top of the furnace. It is probable that very little of the carbon resulting from this reaction ever reaches the hearth, but it does useful work in reducing the carbon dioxide of the limestone and in removing that portion of the oxygen of the ore which has not been removed by carbon monoxide higher in the furnace. From this point of view it appears that the ability of an ore to induce carbon-deposition is equally as important as the ease with which it loses its oxygen."

After recognizing the disadvantageous effects of an excessive deposition of carbon, Mr. Porter concludes by declaring that, these objections being "overcome by suitable design and management of the furnace, it is certainly true that every pound of carbon deposited means a saving of a pound of fuel for the hearth."

He also gives some numerical factors of reducibility for various classes of ores, to be used in formulas for finding the fuel-efficiency of the blast-furnace. These figures indicate that the Mesabi ores are most easily reduced, and these are followed, in the order of their reducibility, by brown hematites, soft red hematites and roasted carbonates, hard red hematites, Clinton "hard red" ore, and magnetites and mill-cinders, the last two being those which require most coke for their reduction.

The foregoing description of the physical and chemical character of the briquette produced by the Gröndal method, shows it to have all the qualities of an ore that can be reduced in the blast-furnace with the least coke. It is porous, so that by the dissociation of the carbon monoxide in the upper part of the stack, the fine carbon is deposited throughout its mass. Furthermore, the briquette is a hematite, and therefore not open to the usual (and, as can be seen from Mr. Porter's figures,

[7] *Trans.*, xlii., p. 191 (1912).

well-founded) objection of blast-furnace managers to the use of too large a percentage of magnetite in the burden.

It is the rapid reduction of the briquettes in the blast-furnace that has made them so popular in Sweden. The use of from 25 to 50 per cent. of briquettes in the burden of the charcoal blast-furnaces of that country has been shown to reduce by from 15 to 25 per cent. the charcoal-consumption per ton of pig-iron; 50 per cent. of briquettes in the burden giving the best charcoal-economy. In Sweden, from 500,000 to 600,000 tons of pig-iron are produced yearly. The annual product of briquettes, averaging 64 per cent. of iron, is from 300,000 to 350,000 tons, representing about 200,000 tons, or about one-third of the total production, of pig-iron. This means a yearly saving for the country of 400,000 cu. m. of charcoal,[8] an item of importance in these times of increasing scarcity of wood suitable for charring. If so great a saving has been made in charcoal-furnaces, it is not too much to believe that a corresponding saving in coke-furnaces is both practicable and important.

I have figures from a furnace in Belgium which has been using imported Swedish concentrate-briquettes in a mixture with calcined Bilbao spathic ore. With 70 per cent. of briquettes and 30 per cent. of Bilbao ore in the burden, the coke-consumption was 1,760 lb. per ton of pig-iron, whereas, with all Bilbao ore, it had been 2,398 lb. The iron-content of the Bilbao ore was 50 per cent.; of the briquettes, 65 per cent. By the use of the briquettes, the output of the furnace was increased from 20 to 25 per cent., with a corresponding saving in wages and general charges.

From the United States I have no definite figures. The briquettes produced here have been used in such small lots at various plants that no valuable data have been obtained. I have been recently informed, however, that at Mayville the coke-consumption in the blast-furnace is considerably reduced by their use. The briquetting-plant there has been in operation so short a time that it is too early to expect authoritative figures.

For use in open hearth-furnaces, the briquettes are emi-

[8] G. Gröndal, *Stahl und Eisen*, vol. xxxi., No. 14, p. 537 (Apr. 6, 1911).

nently fitted, being rich in iron, free from noxious substances, and in lump form, of sufficient weight to sink through the slag cover.

5. *The Practical Operation of the Gröndal Briquetting-Plant.*

The fine ore to be briquetted must contain sufficient moisture to maintain its brick-form after pressing. Too much moisture affects badly the work of the presses; too little makes the briquettes dusty and causes considerable spilling in pressing. The proper percentage of moisture varies with the hygroscopic qualities of the ore. Concentrated magnetites have to be de-watered to 8 or 9 per cent.; fine pyrites-cinder can carry from 15 to 18 per cent. and still give good results. The tempering is done in the simplest manner by a sprinkling-pipe or water-hose. The man who watches the feeding of the presses soon learns by the feeling of the ore whether it has the right moisture-content. The delivery of the ore to the presses is in modern plants performed mechanically at a small expense. In most of the present installations, drop-presses of the Dorstener type, developed by Dr. Gröndal, are used; but on account of the usually rather high cost of maintenance of these presses, it is likely that toggle-presses of heavy construction will be substituted in future plants.

The standard size of the briquettes is 6 by 6 by 2.5 in. Two tiers are loaded edgewise on each car, so that the load stands 12 in. high. At the Duquesne plant, briquettes of the size of standard red brick—2.5 by 4.5 by 8 in.—are made, and are loaded three, or even four, tiers high. Care is taken to place them on the cars so that the gases can penetrate the load and heat the bottom row as thoroughly as the top one. The loading is done by hand, and constitutes the only hand-labor around the plant. This work, however, is so laid out as to make it as easy as possible. The press-man removes the briquettes as they are delivered by the press, and places them on the car, which is pushed close to him. He does not need to move from his place during his work; and, although he handles only 10 or 12 lb. each time he turns, he can place 30 tons in a 12-hr. shift. The press delivers from 12 to 16 briquettes a minute, so that enough idle time is allowed for changing cars. The present endeavor is to eliminate this

manual labor, which, it must be admitted, is quite strenuous and, with wages at about $2.10 per day, represents from 7 to 10 cents of the briquetting-cost per ton.

The loaded cars are pushed through the furnace at intervals, one car being admitted at a time. This car pushes the others forward, so that, as the last car is introduced, the first is discharged from the furnace. The pushing, which is done by a hydraulic ram or some similar contrivance, requires little power. The discharged car is unloaded either by being pushed under a plow, which scrapes the briquettes over the sides of the car, or by being tipped endwise. Either arrangement can be made entirely automatic; so that, in a four-furnace plant, two men can take care of all the cars as they come out, unload them, and send them back to the presses over a return-track with endless-chain haulage. The frequency with which the cars are charged depends upon the nature of the ore. If it is high in sulphur, they may have to be charged on that account at a slower rate. At Mayville cars are charged every 10 min. The furnaces there are 195 ft. and the cars 6 ft. 6 in. long. Each furnace, therefore, contains simultaneously 30 cars, which require (since one is pushed in every 10 min.) 5 hours to pass through. At Bayonne the furnace is only 143 ft. long. One car is pushed in every 18 min., so that it takes 6.5 hours to pass through.

The length of the furnaces (which, as already shown, is quite different in the Mayville and the Bayonne plants) depends upon the nature of the ore to be briquetted. The width has been gradually increased. To begin with, it was not more than 3 ft. In the United States both 5-ft. and 6-ft. furnaces are used, and foundations have now been laid for two, having an inside width of 10 ft. Plans have been drawn for furnaces 15 ft. wide; and I see no reason to prevent even a greater width. A wide furnace, with a capacity of, say, 300 tons of briquettes per 24 hr., would show a still greater heat-economy than present plants. The development of the process is advancing in this direction.

Simultaneously, improvements in the design of the furnace are introduced in every new installation, in order to strengthen details which have proved defective in previous plants, and to reduce the cost of maintenance. Good results have been attained in these respects. The furnaces themselves will stand

for years without the walls or the arch having to be touched; and the repair-cost on cars amounts to only a few cents per ton. Mechanical labor-saving devices are introduced everywhere, so that the labor-cost is being lowered.

The fuel-consumption is low. In plants treating magnetic concentrates, the amount of coal used in the gas-producers averages 7 per cent. of the weight of the briquettes; and there are plants in Sweden using as little as 5 per cent. At a plant in the United States where pyrites-residues are briquetted, and crude oil is used as fuel, the coal-consumption is reported to be 15 gal. per ton of material briquetted. It is obvious that, if the ore is heavy, like magnetic concentrates, for instance, the percentage of fuel used, if calculated on the original charge, will be lower than in the treatment of ore that contains a large amount of combined water and other volatile matter. With such ore, a shrinkage in weight of from 15 to 20 per cent. has to be taken into consideration.

Discussion.

In connection with the presentation of his paper in oral abstract, Mr. Hansell exhibited samples of briquettes, showing their porosity, and the change of surface produced by burning.

Alfred H. Cowles, Sewaren, N. J.—I am familiar with this furnace, and I wish to point out that the larger it is, the greater is its efficiency, and the longer its life. In Europe, experiments have been made with small, short furnaces of this character, accommodating narrow cars; whereas Mr. Hansell says that there is in this country a furnace 180 ft. long and 11 ft. wide. The American furnaces, moreover, differ in design from those used in Europe; and we may expect from these larger furnaces not only greater efficiency, but also greater durability —the latter advantage being due to the fact that, in these large furnaces, projecting brick walls of greater thickness can be provided, to prevent the heat from attacking the sides of the cars, by means of bricks which, over-reaching these iron surfaces, furnish a protective cover to them. In other words, in these large furnaces, the iron sides of the cars, slipping through under the side-walls of the furnace, are more effectively protected than in small furnaces, against the action of the heat.

I think we may expect that, in large furnaces, such as are building in this country, the great mass of magnetites can be effectively treated at low cost, and with small consumption (probably not more than 4 per cent.) of fuel.

[Mr. Cowles mentioned also the diminution of phosphorus and sulphur in the products of smelting the briquettes, as shown by the analyses presented in the paper; but Mr. Hansell declared that the briquetting process did not eliminate phosphorus, and explained that the difference in phosphorus shown by the analyses between the crude ore and the briquettes was due to an intervening concentration of the ore, before it was briquetted. This explanation, which was at once accepted by Mr. Cowles, is published simply to prevent any similar natural misinterpretation of the chemical analyses referred to.]

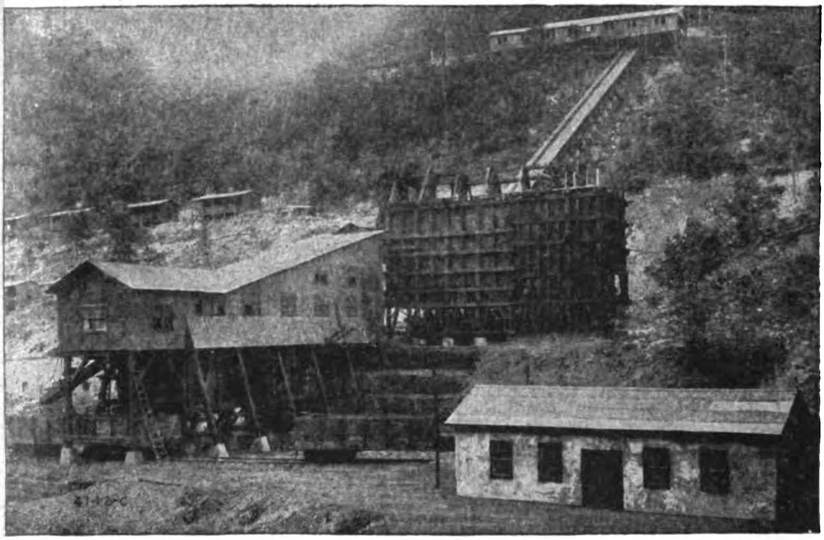
No. 66 JUNE 1912

Bulletin of the American Institute of Mining Engineers.

CONTENTS:

SECTION I.—INSTITUTE ANNOUNCEMENTS.

SECTION II.—PAPERS AND DISCUSSIONS.



Jeffrey Tipple Equipment and Cable Retarding Conveyer, Roanoke Coal & Coke Co., Bear Hollow, W. Va.

Minimum breakage in the handling of coal increases the market value, as well as a demand for the product.

Jeffrey Wire Cable Conveyers solve the problem of breakage where coal has to be lowered from an upper to lower level.

They operate with minimum power and expense, and will often pay for themselves in a single season.

We have designed Conveyers of this type handling up to 500 tons per hour.

Write for Bulletin No. 33, as well as other Jeffrey Catalogs on complete Tipple and Coal Mine Equipments, in which you may be interested.

THE JEFFREY MFG. CO., Columbus, Ohio

New York Montreal Charleston, W. Va. Birmingham St. Louis Seattle
Boston Pittsburgh Atlanta, Ga. Chicago Denver 6-15-12

BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

No. 66 JUNE 1912

PUBLISHED MONTHLY
BY THE AMERICAN INSTITUTE OF MINING ENGINEERS
at 124 to 128 N. Seventh St., Philadelphia, Pa.
Guy R. Overend, Publication Manager.
Editorial Office, 29 West 39th St., New York, N. Y.
JOSEPH STRUTHERS, Ph.D., Editor.
Cable address, "Aime," Western Union Telegraph Code.

Subscription (including postage), $10 per annum; to members of the Institute, public libraries, educational institutions and technical societies, $5 per annum.
Single copies (including postage), $1 each; to members of the Institute, public libraries, etc., 50 cents each.

Entered as second class matter, October 16, 1911, at the post office at Philadelphia, Pa., under the Act of March 3, 1879.

TABLE OF CONTENTS.

SECTION I. INSTITUTE ANNOUNCEMENTS.

SECTION II. TECHNICAL PAPERS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

All communications concerning the contents of this Bulletin should be addressed to JOSEPH STRUTHERS, Ph.D., Secretary and Editor, 29 W. 39th St., New York, N. Y.

OFFICERS.

For the year ending February, 1913.

COUNCIL.*

PRESIDENT OF THE COUNCIL.

JAMES F. KEMP..New York, N. Y.

(Term expires February, 1913.)

VICE-PRESIDENTS OF THE COUNCIL.

S. B. CHRISTY..Berkeley, Cal.
R. V. NORRIS..Wilkes-Barre, Pa.
GARDNER F. WILLIAMS..Washington, D. C.

(Term expires February, 1913.)

KARL EILERS..New York, N. Y.
WALDEMAR LINDGREN..Washington, D. C.
BENJAMIN B. THAYER..New York, N. Y.

(Term expires February, 1914.)

COUNCILORS.

ROBERT E. JENNINGS..New York, N. Y.
WILLIAM KELLY..Vulcan, Mich.
HENNEN JENNINGS..New York, N. Y.

(Term expires February, 1913.)

A. E. CARLTON..Cripple Creek, Colo.
W. J. OLCOTT..Duluth, Minn.
E. L. YOUNG..New York, N. Y.

(Term expires February, 1914.)

JOHN H. JANEWAY, Jr..New York, N. Y.
SIDNEY J. JENNINGS..New York, N. Y.
JOSEPH W. RICHARDS..South Bethlehem, Pa.

(Term expires February, 1915.)

SECRETARY OF THE COUNCIL AND EDITOR.

JOSEPH STRUTHERS, 29 W. 39th St..New York, N. Y.

(Term expires February, 1913.)

SECRETARY EMERITUS OF THE COUNCIL.

R. W. RAYMOND..New York, N. Y.

CORPORATION.

JAMES F. KEMP, President; EDMUND B. KIRBY, Vice-President; FRANK LYMAN, Treasurer; GEORGE C. STONE, Secretary; JOSEPH STRUTHERS, Assistant Secretary and Assistant Treasurer.

DIRECTORS.

JAMES GAYLEY, CHARLES KIRCHHOFF, FRANK LYMAN.

(Term expires February, 1913.)

JAMES DOUGLAS, JAMES F. KEMP, ALBERT R. LEDOUX.

(Term expires February, 1914.)

EDMUND B. KIRBY, CHARLES F. RAND, GEORGE C. STONE.

(Term expires February, 1915.)

Consulting Attorneys, Blair & Rudd, New York, N. Y.

* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation.

COMMITTEES.

For the year ending February, 1913.

COUNCIL.

Membership:—Joseph Struthers, Karl Eilers, Sidney J. Jennings, Benjamin B. Thayer, John H. Janeway, Jr.

Publications:—Joseph Struthers, *Chairman;* David W. Brunton, Samuel B. Christy, Albert L. Colby, Nathaniel H. Emmons, Charles H. Fulton, James Gayley, H. O. Hofman, Henry M. Howe, Walter R. Ingalls, James F. Kemp, R. V. Norris, Edward D. Peters, Rossiter W. Raymond, Joseph W. Richards, Robert H. Richards, Albert Sauveur, Henry L. Smyth, Arthur L. Walker.

Iron and Steel Division:—Charles Kirchhoff, *Chairman;* Charles F. Rand, *Vice-Chairman;* Bradley Stoughton, *Secretary;* John Birkinbine, James Gayley, Henry D. Hibbard, Henry M. Howe, Robert W. Hunt, Julian Kennedy, Charles K. Leith, Richard Moldenke, Joseph W. Richards, F. W. C. Schniewind, Felix A. Vogel, Leonard Waldo, William R. Webster.

CORPORATION.

Finance:—Charles F. Rand, James Gayley, George C. Stone.

Library:—James F. Kemp, Charles Kirchhoff, George C. Stone.

Land Fund:—James Douglas, *Chairman*; Theodore Dwight, *Treasurer;* T. F. Cole, Anton Eilers, James Gayley, John Hays Hammond, Charles Kirchhoff, Albert R. Ledoux, Frank Lyman.

INSTITUTE REPRESENTATIVES.

United Engineering Society Trustees:—Joseph Struthers (1913), Theodore Dwight (1914), James F. Kemp (1915).

Joint Conference Committee of the Four National Engineering Societies:—James F. Kemp, Joseph Struthers.

John Fritz Medal Board of Award:—E. Gybbon Spilsbury (1913), R. V. Norris (1914), Charles Kirchhoff (1915), J. F. Kemp (1916).

American Association for the Advancement of Science:—H. O. Hofman, John D. Irving.

Eighth International Congress of Applied Chemistry, New York, September, 1912:—William L. Saunders, George C. Stone.

Sixth Congress of the International Association for Testing Materials, September, 1912:—Robert Forsyth.

Committee No. 24, International Association for Testing Materials:—Henry D. Hibbard.

International Engineering Congress, San Francisco, 1915:—Samuel B. Christy, William C. Ralston, Edwin T. Blake.

Kelvin Memorial Committee:—James F. Kemp, Samuel B. Christy, James Douglas, Joseph Struthers.

Conference to Discuss Patent Laws:—A. F. Lucas, ————, ————.

INSTITUTE ANNOUNCEMENTS.

Adjourned Annual Business Meeting of the Institute.

At the Annual Business Meeting of the Institute, Feb. 20, 1912, it was voted to postpone the consideration of the proposed amendments to the Constitution until June 3, 1912, and the meeting adjourned to reconvene on that date, or on such subsequent date as should be fixed by the Special Committee of Five appointed on Feb. 20, and the Board of Directors of the Institute, acting jointly.

Due to various causes, including absence of two members of the Committee in Europe for two months, it has not been possible for the Special Committee of Five to complete its report in time for preliminary distribution to members of the Institute, and consideration by them prior to June 3, 1912, and it has been mutually agreed by the Special Committee and the Board of Directors to postpone the date at which the adjourned meeting shall be reconvened from June 3, 1912, to Oct. 7, 1912.

By order of the Board of Directors,

JOSEPH STRUTHERS,
Assistant Secretary.

Puget Sound Section.

At a meeting of the Council, May 24, 1912, permission was granted for the establishment of a Local Section, to be known as the Puget Sound Section of the American Institute of Mining Engineers, on the application of the following members of the Institute: Joseph Daniels, Chester F. Lee, Amos Slater, Clancy M. Lewis, Henry Landes, Charles E. Phoenix, Milnor Roberts, M. C. Butler, H. P. Banks, Richard Kleesattel, H. P. Fogh, George W. Evans, I. F. Laucks.

Spokane Local Section.

The third quarterly meeting of the Spokane Local Section of the American Institute of Mining Engineers was opened at Carnegie Library, Wallace, Idaho, Saturday, May 11, 1912, at 10 a. m., with Prof. R. S. McCaffery in the chair, and 100 members and guests present.

After an address of welcome by E. R. Denny, President of the Wallace Board of Trade, and a response by Prof. F. A. Thomson, of Pullman, Wash., the keys of the City were officially turned over to the visitors by Hon. J. H. Taylor, Mayor.

The chairman then called for the papers, which were presented by the authors, and liberally discussed, as follows:

The New Bunker Hill Mill, by R. S. Handy, Mill Superintendent, Bunker Hill & Sullivan Mining & Concentrating Co.

Maquisten Tube-Flotation Process, by O. B. Hofstrand, Constructing Engineer and Metallurgist.

Lead- and Zinc-Separation, by R. S. McCaffery, Professor of Mining and Metallurgy, State University, Moscow, Idaho.

Adjournment was then taken until afternoon, when the party visited the new mill of the Hercules Mining Co., within the city limits. This mill, designed to treat the low-grade lead-silver ores of the Hercules mine, cost about $150,000, and has a capacity of about 500 tons per day. Like other mills in this district, there has been an attempt to reduce costs of milling and make a closer saving; in both particulars the attempt has proved measurably successful. The Hercules Company introduced into this district hand-picking from conveyor-belts, and is carrying on some exhaustive tests with the Franz tables, patented by F. Franz, a local millman, who is now with the company. The table has some special points of merit and is being improved under tests.

At 8 p. m. a banquet was tendered the visitors by resident members and others, and addresses were made by James F. McCarthy, Stanley A. Easton, L. K. Armstrong, Prof. R. S. McCaffery, and Rush J. White.

The following resolutions were passed:

Resolved, That for the marked hospitality and for the many personal and professional courtesies extended by the citizens and mining-men of Wallace and of the Cœur d'Alène district, the members of the Spokane Local Section of the American Institute of Mining Engineers hereby return very sincere thanks and heartfelt appreciation; and, furthermore, instruct the Secretary to send an official copy of this resolution to Mayor J. H. Taylor, of Wallace, and to E. R. Denny, President of the Wallace Board of Trade.

A resolution favoring a State Geological Survey for Idaho was introduced by Prof. C. A. Stewart, Professor of Geology, State University, Moscow, Idaho, and was unanimously indorsed.

On Sunday, May 12, at 8 a. m., a special train took the visitors to the Hecla mine, at Burke, where the electric hoist was inspected. This hoist has been described fully by E. M. Murphy, in a paper read before the Spokane Local Section, and has been mentioned several times in the technical press. As at all other large mines in this district, motive-power and lighting are supplied by electricity, with storage reserve and auxiliary steam reserve. The mine is at its best; milling is done at Gem, a few miles down the canyon.

Leaving Burke, the party proceeded to Mullan, where the Morning mill of the Federal Mining & Smelting Co. was inspected, special attention being centered on the Maquisten tube, which is described in the paper of O. B. Hofstrand. The company, at this mine and elsewhere, however, is making improvements in every part of its mills, and there is a notable increased efficiency, made possible by the Calumet classifier, Esperanza de-waterer, Hardinge, tube, and Huntington mills, Hancock jigs, hand-sorting, etc.

The Morning mill has a capacity of about 1,200 tons per day, but, with the addition of the Maquisten-tube plant, the second unit of which is now being installed, this capacity will be somewhat increased and a much closer saving made possible.

After such a luncheon as is seldom served in a mining-camp, the party proceeded by electric train to the underground station of the mine, 2 miles from the portal. This is the most commodious underground mining-station in the world. The method of hoisting and loading is by compressed air. Mining-operations are not confined to any one point, but most of the ore is raised from below the station-level, and the west face of the mine at points visited showed about 40 ft. of ore of all grades.

The return to Wallace was made in the evening, and on Monday, May 13, the party proceeded to Kellogg, where headquarters was maintained at the Young Men's Christian Association, which has revolutionized social conditions in that portion of the district, where formerly the lawless wrecking of the concentrating plant of the Bunker Hill & Sullivan, and the famous Bull Pen, were incidents in keeping with those less civilized times.

The New Bunker Hill mill-unit was inspected under direction of R. S. Handy, whose paper on this mill, read at the meeting, will be published in a future issue of the *Bulletin*.

Underground through the 2-mile tunnel by electric train along a well-lighted track found the visitors in what has so often been described as the greatest lead-silver mine on earth. This great property will continue its phenomenal record for many years to come under ordinarily favorable conditions.

From here the party divided, some returning home, while others visited the Caledonia, Marsh, Stewart, Success and other properties.

The net profits of the four mines visited, or whose mills were inspected, as given the assessor for the year 1911, were as follows:

Morning, ...	$114,719
Hercules, ...	544,429
Hecla, ...	287,101
Bunker Hill & Sullivan, ...	798,747

The gross value of all the ore produced by the nine leading companies of the district for the same period was $13,375,178. The gross tonnage was 1,418,329 tons.

There is a noticeable determination on the part of the mine-owners to increase the efficiency of the ore-dressing plants. There is a very large tonnage now being mined which would remain in the mines if any reduction of the present tariff-schedules on lead and zinc were made. This tonnage would be permanently lost if not removed in the regular course of mining.

The district last year produced 30 per cent. of all the lead mined in the United States, about 8 per cent. of the silver, and considerable values in zinc, copper, and gold.

Two railways now enter the district—the N. P. Ry., and O-W. R. R. & Nav. Co., with the C., M. & S. P. seeking entry. All the products of the mines go to outside points for treatment.

Much credit is due the local committee, James F. McCarthy, Stanley A. Easton, William J. Hall, and Rush J. White, for the well-ordered program, and the hearty thanks of all members and the guests are extended. C. M. Grubbs, General Agent, N. P. Ry., is also thanked for courtesies given.

RICHARD S. MCCAFFERY, *Chairman.*
L. K. ARMSTRONG, *Secretary.*

Special Notice.

The *Bulletin* is now entered at the Post Office at Second-Class Postage rate of one cent per pound, and in order to preserve this privilege it is necessary that the dues of members be paid within four months of January 1 of each year. If the dues are not paid within the period mentioned, a member's name must be removed from the regular subscription-list and the *Bulletin* mailed at the transient second-class postage rate of one cent for each four ounces or fraction thereof, prepaid by stamps affixed. It is therefore earnestly requested that dues be paid promptly—otherwise the Institute will be put to additional expense of postage and to added labor in removing and replacing names from the regular list, and in maintaining an additional separate mailing-list.

Library Research-Work.

The attention of members of the Institute is again directed to the research-work done by the librarian and his assistants, which should attract special attention from those members who have no access to the literature of subjects in which they may be interested.

During the year 1911 there were 143 searches made for members and non-members of the Founder Societies, and copies of the references have been preserved for the use of others. This work has been largely based on requests sent in by mail, from Japan, South Africa, Mexico, Canada, and England, as well as from different parts of the United States. The Librarian is confident that if it were more widely known that the library is equipped to undertake researches, the demand would increase beyond the ability of the present force to handle it. The library receives more than 700 technical periodicals which are available through the indexes for this special purpose.

Back Volumes of the Transactions.

The Board of Directors has authorized the following offers of sets of back volumes of the *Transactions*, at considerably reduced prices, to Members, Libraries, and Scientific Societies:

		Per Set.
I.	Five volumes, bound in half-morocco, from No. 36 (1906) to No. 40 (1910), ...	$20
II.	Ten volumes, bound in half-morocco, from No. 31 (1902) to No. 40 (1910), including Mexican Volume, . . .	35
III.	Twenty volumes, bound in half-morocco, from No. 21 (1893) to No. 40 (1910), ...	50
IV.	Thirty volumes, bound in half-morocco, from No. 11 (1883) to No. 40 (1910), ...	60
V.	Thirty-nine volumes, bound in half-morocco, from No. 1 (1873) to No. 40 (1910), with the exception of No. 10 (1882), but including index for Volumes Nos. 1 to 35, and Nos. 36 to 40, ...	75
VI.	Nine volumes, bound in half-morocco, from No. 1 (1873) to No. 9 (1881), ...	25

Applications should be addressed to Joseph Struthers, Secretary, 29 West 39th Street, New York, N. Y.

The Emmons Research Fellowship of Economic Geology.

The Committee named below has been formed by friends of Samuel Franklin Emmons, late of the United States Geological Survey, to consider the best method of perpetuating his name. It has been decided that the memorial to him shall take the shape of a Research Fellowship, to be known as the Samuel Franklin Emmons Research Fellowship of Economic Geology, which is to be administered by Prof. James F. Kemp, of Columbia University, New York. Subscriptions are invited by his friends to this fund, which the Committee has fixed at $25,000.

Members of the Institute who desire to contribute to this fund will please communicate with the Treasurer, Benjamin B. Lawrence, 60 Wall Street, New York.

The Committee consists of the following:

GEORGE OTIS SMITH, Director, U. S. Geological Survey, Washington, D. C.
H. L. SMYTH, Harvard University, Cambridge, Mass.
JAMES DOUGLAS, 99 John Street, New York, N. Y.
J. A. HOLMES, Director, Bureau of Mines, Washington, D. C.
JAMES F. KEMP, Columbia University, New York, N. Y.
F. W. BRADLEY, San Francisco, Cal.
J. PARKE CHANNING, 42 Broadway, New York, N. Y.
SEELEY W. MUDD, 1001 Central Building, Los Angeles, Cal.
D. W. BRUNTON, Denver, Colo.
H. FOSTER BAIN, 420 Market Street, San Francisco, Cal.
T. A. RICKARD, London, England.
B. B. LAWRENCE, 60 Wall Street, New York, N. Y.

Regulations for the Committee on Publication.

(*Adopted June* 16, 1911.)

1. The formation of a Publication Committee, consisting of the Secretary-Editor of the Institute, *Chairman*, and of at least twelve specialists, members of the Institute, who are willing to assist in passing on all papers offered for publication.

2. This committee shall perform its functions as follows:

(*a*) On the receipt of a paper by the Secretary, he shall send it to the member of this committee who, in his judgment, is most competent to pass upon it, accompanying the paper with his own opinion of its suitableness for publication, the history of the paper, and any other pertinent information.

(*b*) If the member of the committee and the Chairman agree upon the suitability or unsuitability of the paper, it shall be considered accepted for publication or rejected, as the case may be.

(*c*) If these two do not agree, the paper shall be submitted to a third, and the opinion of two of these three shall decide the matter.

(*d*) If a paper has been refused publication, the author may have the right of appeal, in which case the persons previously passing

on the paper, together with others of the committee (appointed by the President) making five altogether, shall decide the question.

(*e*) If a paper has been accepted for publication, it shall be considered eligible to be placed on the program of a meeting.

3. The placing of a paper upon the program of a meeting does not give it the right to be published in the *Bulletin* or *Transactions* of the Institute; its suitability for publication must in every case be passed upon by the Publication Committee, as provided for in Section 2.

4. In case the Secretary is unable to secure a decision as to the suitability or unsuitability of a paper for publication, as directed in Section 2, before the time of announcing the program of a meeting, he may at his own discretion place the paper upon the program of the meeting, or refuse it a place thereon.

Affiliated Student Societies.

Any society of undergraduates at a technical school, comprising students in any branch of engineering, metallurgy, chemistry, geology, etc., may be recognized by the Council in its discretion as an Affiliated Student Society. A circular giving details of the plan of affiliation may be obtained on application to the office of the Secretary of the Institute.

The following societies have been placed by authority of the Council on the above list:

AFFILIATED STUDENT SOCIETIES.

The Mining Society of the Sheffield Scientific School, Yale University, New Haven, Conn. *President*, Karl C. Stadtmiller; *Secretary*, S. B. Gordy.

The University of Illinois Student Branch of the American Institute of Mining Engineers, Champaign, Ill. *President*, Leonard V. Newton; *Secretary*, L. W. Swett.

The Engineering Society of the University of Nevada, Reno, Nev. *President*, D. E. Bruce; *Secretary*, R. M. Seaton.

The University of Wisconsin Mining Club, Madison, Wis. *President*, Rudolph J. Stengl; *Secretary*, Mack C. Lake.

The Mining and Geological Society of Lehigh University, South Bethlehem, Pa. *President*, William E. Fairhurst; *Secretary*, Carl W. Mitman.

The School of Mines Society of the University of Minnesota, Minneapolis, Minn. *President*, Emory P. Baker.

The Mining Engineering Society of the Massachusetts Institute of Technology. *President*, L. B. Duke; *Secretary*, Lionel H. Lehmaier.

The Student Auxiliary Society of the American Institute of Mining Engineers of the University of Kansas, Lawrence, Kan. *President*, A. H. Mangelsdorf; *Secretary*, C. J. Hainbach.

The Associated Miners of the University of Idaho, Moscow, Idaho. *President*, James W. Gwinn; *Secretary*, J. Wallace Strohecker.

The State College of Washington Mining and Geological Society, Pullman, Wash. *President*, H. E. Doelle; *Secretary*, B. R. Kinney.

The Tejas Technical Society, School of Mines, University of Texas. *President*, G. C. Cartwright; *Secretary*, David S. Alley.

The Ohio State University Student Branch of the American Institute of Mining Engineers, Columbus, Ohio. *President*, Hugh B. Lee; *Secretary*, E. P. Elliott.

The Stanford Geology and Mining Society, Stanford University, Cal. *President*, B. E. Parsons; *Secretary*, E. D. Nolan.

The Senior Mining Society of Columbia University, New York, N. Y. *President*, Roger L. Strobel; *Secretary*, Clark G. Mitchell.

Mining Association of the University of California, Berkeley, Cal. *President*, Frank L. Wilson; *Secretary*, Stanley L. Arnot.

Tufts College Chemical Society, Tufts College, Mass. *President*, P. G. Savage; *Secretary*, W. S. Frost.

University of Washington Mining Society, Seattle, Wash. *President*, Horace H. Crary; *Secretary*, Clinton R. Lewis.

Student Branch of the American Institute of Mining Engineers, Iowa State College, Ames, Iowa. *President*, M. B. Hadley; *Secretary*, R. L. Hurst.

Missouri Mining Association of the Missouri School of Mines, Rolla, Mo. *President*, D. L. Forrester; *Secretary*, J. S. Irwin.

The Pick and Shovel Club of the Case School of Applied Science, Cleveland, Ohio. *President*, L. B. Riddle; *Secretary*, S. C. Stillwagon.

Colorado School of Mines Scientific Society, Golden, Colo. *President*, Alan Kissock; *Secretary*, George Wilfley.

Mining Engineering Society of the University of Arizona, Tucson, Ariz. *President*, James J. Flanigan; *Secretary*, H. O. Coles.

How to Use the "Transactions" of the Institute.

Buy a copy of the Complete Analytical and Alphabetical Index of Volumes I. to XXXV., inclusive; also the new Index of Volumes XXXVI. to XL.

Whether you do or do not own a full set of the *Transactions*, these Indexes will make all of the material contained in the forty volumes available at once without detailed research into each volume separately. Moreover, an easy search will show what particular papers you need to know more about, and perhaps to study. Thus, any person possessing these Indexes can ascertain at once what has been published in the *Transactions* on a given question, and can learn, by writing to the Secretary, what is its nature, whether it is still to be had in pamphlet form, where it can be consulted in a public library, at what cost it can be copied by hand, etc., etc.

In short, to those who own complete sets of the *Transactions*, these Indexes will be a great convenience; but to those who do not, they will be a professional necessity.

The Index Volumes I. to XXXV. is an octavo of 706 pages, containing more than 60,000 entries, duly classified with sub-headings, and including abundant cross-references. The limited edition is becoming exhausted. The new Index, Volumes XXXVI. to XL., supplementing the Index Volumes I. to XXXV., brings the classified references up to the date of Volume XL., June, 1910. Prices: Index Volumes I. to XXXV., bound in cloth, \$5; bound in half-morocco, to match the *Transactions*, \$6. Index Volumes XXXVI. to XL., bound in cloth, \$1.50; bound in half-morocco, \$2.50. The delivery charges will be paid by the Institute on receipt of the above price.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
AMERICAN INSTITUTE OF MINING ENGINEERS.
UNITED ENGINEERING SOCIETY.

WILLIAM P. CUTTER, Librarian.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

The Library contains about 42,000 volumes, including sets of technical periodicals and the publications of scientific and technical societies.

The members of the Institute, with few exceptions, are by the very nature of their profession forced to spend a large portion of their time in localities isolated from sources of information. To such members the Library can render valuable service through correspondence, and letters requesting information will receive special attention. The Library is prepared to furnish references and copies of articles on mining and metallurgical subjects; to determine, if possible, the existence of mining-maps, and to furnish general information as to the geology and mineral resources of all countries as far as these resources are known and published.

It is hoped that the members of the Institute will avail themselves freely of this special service. The Library will welcome inquiries on engineering subjects, and furnish information as far as such information is to be obtained.

All communications should be made as definite as possible so that the information received may be what is desired and not include collateral matter which may not be of interest. In this way the time spent in searching for such collateral matter will be saved, and as a result the information will be sent more promptly and in more usable shape.

The members of the Institute can be of service to the Library by forwarding copies of mining-reports, maps privately issued, and similar material, which will be classified, indexed, and made available to other members.

Suggestions for additions to the Library, either by purchase or personal solicitation as gifts, will be welcomed. It is hoped that members while in the city will use the Library freely, and assurance is given that most careful service will be rendered to them.

Library Accessions.

May 1 to May 31, 1912.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

AMERICAN INSTITUTE OF CONSULTING ENGINEERS. Report of the Annual Meeting, Jan. 16, 1912. New York, 1912. (Gift of American Institute of Consulting Engineers.)

AMERICAN MUSEUM OF NATURAL HISTORY. Annual Report, 43d. New York, 1912. (Exchange.)

ASSOCIATION DES INGENIEURS SORTIS DE L'ECOLE DE LIÉGE. List des Members Annee 1912. Liége, 1912. (Exchange.)

BANKERS' DIRECTORY, 1912. New York, 1912. (Purchase.)

DIE BERGWERKE UND SALINEN IM NIEDERRHEINISCH-WESTFÄLISCHEN BERGBAUBEZIRK IM JAHRE 1911. Essen Ruhr, 1912. (Gift of Vereins für die Bergbaulichen Interessen.)

BIBLIOGRAPHIE DER FREMDSPRACHIGEN ZEITSCHRIFTENLITERATUR. Band I., 1911. By F. Dietrich. Leipzig, 1911. (Purchase.)

DIE BINÄREN METALLEGIERUNGEN. Teil II. By K. Bornemann. Halle a/S., 1912. (Purchase.)

CANADA. MINES DEPARTMENT. Annual Report on the Mineral Production of Canada, 1910. Ottawa, 1912. (Exchange.)

CAPE OF GOOD HOPE. Geological Map. Sheets XIX., XXVI. 1912. (Exchange.)

CATALOGUE DE LA BIBLIOTHEQUE DE LA COMMISSION CENTRALE DE STATISTIQUE. Tome VII. Bruxelles, 1911. (Gift of Ministère de l'Interieur de Belgique.)

CONCENTRATION OF GAS LIQUOR AND UNGER AMMONIA STILLS. Stirring and Injecting Milk of Lime with Compressed Air. Chicago, n. d. (Gift.)

CONGRESO CIENTIFICO (1° PAN AMERICANO). Agronomia y Zootecnia. Volumen XV. Santiago de Chile, 1911. (Gift of Congreso Cientifico, 1° Pan-Americano.)

CONNECTICUT. STATE GEOLOGICAL AND NATURAL HISTORY SURVEY. Bulletin No. 19. Hartford, 1912. (Exchange.)

EISENHOCHOFENSCHLACKEN, IHRE EIGENSCHAFTEN UND IHRE VERWENDUNG. By Hans Fleissner. Halle a/S., 1912. (Purchase.)

EMMONS, SAMUEL FRANKLIN, MEMOIR. By Arnold Hague. (Reprinted from *Bulletin of the Geological Society of America*, vol. 23, pp. 12–28.)

GABBROS AND ASSOCIATED ROCKS AT PRESTON, CONNECTICUT. (Bulletin No. 492, U.S. Geological Survey.) Washington, 1912. (Exchange.)

GEOLOGICAL INSTITUTION OF UNIVERSITY OF UPSALA. Bulletin. Vol. XI. Upsala, 1912. (Exchange.)

GEOLOGICAL SOCIETY OF LONDON. List of Members, April, 1912. Piccadilly, 1912. (Exchange.)

GLÜCKAUF. Index to vol. 38, 1902. Essen, 1902. (Purchase.)

HANDBOOK OF COST DATA FOR CONTRACTORS AND ENGINEERS. Ed. 2. By H. P. Gillette Chicago–New York, 1910. (Purchase.)

HISTORY OF GOLD MINING IN THE UNITED STATES. By R. A. F. Penrose, Jr. (Reprinted from *Popular Science Monthly*, February, 1912.) N. p., n. d. (Gift of Author.)

ILLINOIS. BUREAU OF LABOR STATISTICS OF THE FREE EMPLOYMENT OFFICES. Annual Report, 13th, 1911. Springfield, 1912. (Gift of Illinois Bureau of Labor.)

INSTITUTION OF MECHANICAL ENGINEERS. List of Members, 1912. London, 1912. (Exchange.)

KÖNIGLICHE TECHNISCHEN HOCHSCHULE IN MÜNCHEN. 47 pamphlets. (Gift of Königliche Technischen Hochschule in München.)

LEHRBUCH DER MINERALOGIE. Ed. 5-6. By F. Klockmann. Stuttgart, 1912. (Purchase.)

MARYLAND. GEOLOGICAL SURVEY. Lower Cretaceous. Baltimore, 1911. (Exchange.)

——— Prince George's County and Maps. Baltimore, 1911. (Exchange.)

——— Volume IX. Baltimore, 1911. (Exchange.)

METHODS OF AIR ANALYSIS. By J. S. Haldane. London, 1912. (Purchase.)

MINING CONDITIONS UNDER THE CITY OF SCRANTON, PA. With maps. (Bulletin No. 25, U. S. Bureau of Mines.) Washington, 1912. (Exchange.)

NEW BRUNSWICK. CROWN LAND DEPARTMENT. Annual Report, 51st. Fredericton, 1912. (Gift of Crown Land Department.)

NEW BRUNSWICK, PROVINCE OF. Acts Relating to Mines and Minerals, etc. (Reprinted from the Consolidated Statutes of 1903.) N. p., n. d. (Gift of Crown Land Department.)

NEW INTERNATIONAL YEAR BOOK, 1911. New York, Dodd, Mead & Co., 1912. Price, $5. (Gift of Publishers.)

[NOTE.—The method and quality of this annual encyclopedia are too well known to need detailed description; for it is the fifth of a series begun in 1908, with the appearance of the New International Year Book for 1907, and there has been (as, indeed, there needed to be) no change in its plan or scope, while the accuracy, thoroughness and critical judgment of its execution have been maintained from the beginning at a standard of excellence as high as that of the formal work in many volumes which it is designed to supplement. All authors, editors and students know that the chief difficulty which they encounter in their researches is the lack of trustworthy authorities concerning recent events. One cannot confidently rely upon the newspapers—and, besides, one usually cannot find the old newspaper containing the vaguely remembered paragraph desired for illustration or authority. The very things with which our mouths, if not our heads, are filled—the current topics and burning questions of the day—are those of which we need exact knowledge in the highest, and possess it in the lowest, degree. A good year-book for 1911 is likely to be used oftener and with more immediately valuable results than all the other historical books or cyclopedias in the library. But the usefulness of those other books is not in the least disparaged by this statement. Indeed, there is no greater folly than the attempt to supersede them by condensing or carrying forward their contents in an annual volume of this kind. That folly has been avoided from the beginning in this particular year-book. It is *new*, from cover to cover, and it is devoted, without unnecessary repetition of old material, to the events and topics of the year it reports. The result is, that these subjects are treated with adequate clearness and fullness, unincumbered by the load of left-over information or "permanent standing matter." What we want of a year-book is that it shall supplement, not re-state, what earlier books have told us already.

And certainly the year 1911 had enough affairs and events of its own to fill such a volume. Not to mention the multiform developments in American politics and sociology—the proceedings of Congress under the Democratic control of the House of Representatives; the operations of the Sherman law and its construction by the Supreme Court; the prosecution of sundry "Trusts;" the performances of the trade-unions; the McNamara trial; the reciprocity agreement with Canada; the arbitration treaties, and a hundred other all-important things concerning which we are all still saying so much more than we actually know or correctly remember—not to mention these subjects, as I say (though only rhetorically, because I have in fact mentioned them), there were events of world-wide importance in other parts of the world, of which our knowledge, and therefore our intelligent appreciation, is lamentably deficient. The great constitutional conflict in Great Britain; the controversy over Morocco; the war begun by Italy upon Turkey; the trouble in Persia; the revolution in China, and other developments in the far East—these are among the topics treated in this book. But, besides these dynamic records of movement and action, the volume contains what we may call static records, in its report, upon the latest official or statistical authority, of the present condition of all countries—their population, trade, etc.—R. W. R.]

NEW SOUTH WALES. MINERAL RESOURCES. No. 14. Sydney, 1911. (Exchange.)

PENNSYLVANIA. GENERAL ASSEMBLY. Laws of the General Assembly of the Commonwealth of Pennsylvania. 1911. Harrisburg, 1911. (Exchange.)

——— Insurance Commission. Insurance Laws, 1912. Harrisburg, 1912. (Exchange.)

——— Internal Affairs, Secretary. Annual Report, parts I.–IV., 1910. Harrisburg, 1911. (Exchange.)

——— Mines Department. Parts I., II., 1910. Harrisburg, 1911. (Exchange.)

——— State Librarian. Report, 1910. Harrisburg, 1911. (Exchange.)

——— Smull's Legislative Hand Book, 1911. Harrisburg, 1911. (Exchange.)

PRESS REFERENCE LIBRARY (Southwest edition). Notables of the Southwest. Los Angeles, 1912. (Gift of *Los Angeles Examiner.*)

SANITARY PROBLEMS OF THE BOARD OF WATER SUPPLY. By A. J. Provost, Jr. (Reprinted from Municipal Engineers of the City of New York, 1911.) N. p., n. d. (Gift of Author.)

SOCIETÀ TOSCANA DI SCIENZE NATURALI. Atti. Vol. XXVII. Pisa, 1911. (Gift of Società Toscana di Scienze Naturali.)

SURFACE WATER SUPPLY OF THE UNITED STATES, 1910. Part V.—Hudson Bay and Upper Mississippi River. (Water Supply Paper No. 285, U. S. Geological Survey.) Washington, 1912. (Exchange.)

TIN MINING INDUSTRY AND THE DISTRIBUTION OF TIN ORES IN NEW SOUTH WALES. (Mineral Resources, No. 14.) Sydney, 1911. (Exchange.)

U. S. BUREAU OF MINES. Annual Report of the Director of the Bureau of Mines, 1st., 1911. Washington, 1912. (Exchange.)

U. S. COAST AND GEODETIC SURVEY. The Effect of Topography and Isostatic Compensation upon the Intensity of Gravity. Geodesy. Washington, 1912. (Exchange.)

U. S. DEPARTMENT OF COMMERCE AND LABOR. Foreign Commerce and Navigation of the United States, 1911. Washington, 1912. (Exchange.)

U. S. GEOLOGICAL SURVEY. Bulletin No. 492. Washington, 1912. (Exchange.)

——— Folios. Nos. 177, 178, 182. Washington, 1911, 1912. (Exchange.)

——— Water Supply Paper Nos. 279, 285. Washington, 1912. (Exchange.)

U. S. NATIONAL MUSEUM. Report on the Progress and Condition of the U. S. National Museum for the Year Ending June 30, 1911. Washington, 1912. (Exchange.)

UNIVERSITY OF WISCONSIN. Alumni Directory, 1849–1911. Madison, 1912. (Exchange.)

VEREIN FÜR DIE BERGBAULICHEN INTERESSEN IM OBERBERGAMTSBEZIRK DORTMUND. Jahresbericht, 1911. I. (Allgemeiner) Teil. Essen Ruhr, 1912. (Exchange.)

WALLAROO & MOONTA MINING & SMELTING CO., LTD. Reports and Statements of Accounts. Annual Report, 22d. Adelaide, 1912. (Gift of Wallaroo & Moonta Mining & Smelting Co., Ltd.)

WATER RESOURCES OF THE PENOBSCOT RIVER BASIN, MAINE. (Water Supply Paper No. 279, U. S. Geological Survey.) Washington, 1912. (Exchange.)

GIFT OF HILL PUBLISHING CO.

ALDERSON, V. C. Practical Economies Practiced in Metalliferous Mining and Smelting. N. p., n. d.

AUSTRALIA. COMMONWEALTH BUREAU OF CENSUS AND STATISTICS. Monthly Summary of Australian Statistics, January, 1912 (Bulletin No. 1). Melbourne, 1912.

CANADA. DEPARTMENT OF MARINE AND FISHERIES. Papers relating to the Application of the Sanitary District of Chicago for Permission to Divert 10,000 cubic feet of water per second from Lake Michigan. Ottawa, 1912.

CONNECTICUT. LABOR STATISTICS BUREAU. Bulletin No. 4. Hartford, 1911.

GUILLEMAIN, C. Theorie und Praxis der Staubverdichtung und der Reinigung und Entstaubung von Gasen. Halle a/S., 1911.

ILLINOIS WATER SUPPLY ASSOCIATION. Proceedings of 4th meeting, 1912. Urbana, 1912.

INGRIA, R. Le Fondazioni delle opere terrestri e idrauliche e notizie sui sistemi piu in uso in Italia. Milano, 1912.

KAISER, E. W. Zusammensetzung der gebräuchlichen Metallegierungen. Halle a/S., 1911.

MEMOIRE DESCRITTIVE DELLA CARTA GEOLOGICA D'ITALIA. Vol. XIV. Bologna, 1911.

——— ——— Atlante. Bologna, 1911.

MIAMI COPPER CO. Annual Report, 1911. New York, 1911.

MURRAY, T. A. Prevention of the Pollution of Canadian Surface Waters. Ottawa, 1912.

NOUVEAUTÉ EN MÉTALLURGIE. Paris, n. d.

RALLI, G. La Consommation de Combustible dans la Fusion des Minerais de Cuivre et Plomb. Liège, 1911.

LA ROSE CONSOLIDATED MINES CO. Annual Report, 5th, 1911. New York, 1911.

SALIERS, E. A. COAL MINER. Bethlehem, 1912.

SASKATCHEWAN DEPARTMENT OF PUBLIC WORKS. Annual Report, 1910–1911. Regina, 1911.

SCHIFFNER, C. Einführung in die Probierkunde. Halle a/S., 1912.

SOUTH AUSTRALIA. STATISTICAL REGISTER, 1910. Adelaide, 1911.

THARSIS SULPHUR & COPPER CO. Report by the Directors, 1912. Glasgow, 1912.

TONOPAH BELMONT DEVELOPMENT CO. Annual Report, 9th, 1912. Philadelphia, 1912.

U. S. EDUCATION COMMISSIONER. Report, 1911, Vol. I. Washington, 1912.

UTAH COPPER CO. Annual Report, 7th, 1911.

VALENTINI, C. Sistemazione dei Torrenti e dei Bacini Montani. Milano, 1912.

GIFT OF W. R. INGALLS.

BABCOCK & WILCOX, LTD. Steam. Ed. 31. New York, 1899.

BELGIUM. ITS INSTITUTIONS, INDUSTRIES AND COMMERCE. Brussels, 1904.

BELGIUM. MINISTERE DE L'INDUSTRIE ET DU TRAVAIL. Statistique des Industries Extractives et Métallurgiques, 1905. Bruxelles, 1906.

CARMICHAEL BRADFORD PROCESS OF DESULPHURISING. Broken Hill, n. d.

CHALON, P. F. Les Richesses Minérales de l'Algerie et de la Tunisie. Paris, 1907.

CHAPMAN, ROBT. H. Deserts of Nevada and Death Valley. Washington, 1906. (Reprinted from *National Geographic Magazine*, Sept., 1906.)

COLORADO BUREAU OF MINES. Bulletin No. 6. Denver, 1906.

——— Report, 1899–1900, 1905–1906. Denver, 1900, 1906.

COLORADO. GEOLOGICAL SURVEY. Report, 1st, 1908. Denver, 1909.

CONTINENTAL IRON WORKS. Morison Suspension Furnaces for Internal Furnace Tubular Boilers. New York, n. d.

DA CUNHA, A. L'Année Technique, 1905. Paris, 1905.

DANNEEL, H. Specielle Elektrochemie, part I. Halle a/S., 1903. (Handbuch der Elektrochemie.)

DAVIS, J. F. Historical Sketch of the Mining Law in California. Los Angeles, 1902.

DELAHAYE, P., AND PEREYRA, G. Étude sur les Aréomètres Baumé. Paris, 1875.

DENVER, NORTHWESTERN & PACIFIC RAILWAY. General Information. Denver, 1907.

——— Hydrocarbon Field of Western Colorado, Eastern Utah. August, 1906.

——— Yampa Coal Field. August, 1906.

DEVELOPMENT CO. OF AMERICA. The Properties in which . . . is interested. N. p., n. d.

ELLS, R. W. Notes on the Mineral Fuel Supply of Canada. (From *Transactions Royal Society of Canada*, 2d Ser., Vol. 12, Sect. IV.) N. p., 1906.

FERCHLAND, P. Elektrochemische Industrie Deutschlands. Halle a/S., 1904.

——— and REHLÄNDER, P. Die elektrochemischen Deutschen Reichspatente. Halle a/S., 1906.

GERDES, PETER. Einführung in die Elektrochemie. Halle a/S., 1902.

GILPIN, E. Minerals of Nova Scotia. Halifax, 1901.

GREAT BRITAIN. ALKALI, &c., WORKS. Annual Report, 42d. London, n. d.

——— Straits Settlements. Reports on the Federated Malay States, 1906. London, 1907.

GREGORY, J. W. Mount Lyell Mining Field, Tasmania. N. p., n. d.

GRIMSLEY, G. P. Oil, Gas and Glass, Chemical Industries and Minerals in Kansas. Topeka, 1903.

GUANAJUATO CONSOLIDATED MINING & MILLING CO. Gold and Silver Mining and Milling Industry. Guanajuato, n. d.

HERBST. Der Bergbau auf der Lütticher Weltausstellung. Essen (Ruhr), 1906.

IDAHO. INSPECTOR OF MINES. Report, 1899–1902, 1905. Boise, 1900–1902, 1906.

INTERNATIONALEN ANALYSEN KOMMISSION AN DEN VI. INTERNATIONALEN KONGRESS FÜR ANGEWANDTE CHEMIE IN ROM, 1906. Bericht. Zurich, 1906.

LAWTON, C. DE WITT. Review of Lake Superior Copper Mining and Sketch of the History and Operations of the Quincy Mining Co., 1907. New York, 1907.

LE BLANC, MAX. Die Darstellung des Chroms und Seiner Verbindungen mit hilfe des elektrischen Stromes. Halle a/S., 1902.

LISBOA, M. A. R. Sul de Mato Grosso Geologia, industria Mineral, Clima, Vegetacão, solo Agricola, Industria Pastoril. Rio de Janeiro, 1909.

MASSACHUSETTS. COMMISSIONER OF CORPORATIONS. Laws relating to Business Corporations. Boston, 1906.

MENSCH, L. J. Architects' and Engineers' Handbook of Reinforced Concrete Constructions. Chicago, 1904.

MEYER, R. Jahrbuch der Chemie. Year 11, 12, 15. Braunschweig, 1902–1903, 1906.

——— ——— General Register. 1891–1900. Braunschweig, 1903.

MINES OF AFRICA. 1910–1911. London, 1911.

MINERAL RESOURCES OF KANSAS. 1899, 1900–1901. Lawrence, 1900, 1902.

MINING JOURNAL (RUSSIAN). Vol. 4, Nos. 11–12. St. Petersburg, 1911.

MISSOURI. STATE LEAD AND ZINC MINE INSPECTOR. Annual Report, 15th, 16th. Jefferson City, 1902–1903.

MÖLLER, JOH. Die elektrochemische Reduktion der Nitroderivate Organischer Verbindungen. Halle a/S., 1904.

NATAL (S. A.). SURVEYOR GENERAL'S DEPARTMENT. Third and Final Report of the Geological Survey of Natal and Zululand. London, 1907.

NEUBURGER, A. Beilage zum Kalender für Elektrochemiker, 1903. Berlin, 1903.

NEUMANN, BERNHARD. Elektrometallurgie des Eisens. Halle a/S., 1907.

NEW JERSEY. BUREAU OF STATISTICS OF LABOR AND INDUSTRIES. Annual Report, 34th. Camden, 1912.

NIESS, HERMANN. Die Bekämpfung der Wassersand (Schwimmsand) Gefahr beim Braunkohlenbergbau. Freiberg in Sachsen, 1907.

NISSENSON, H. Einrichtungen von Elektrolytischen Laboratorien . . . Halle a/S., 1903.

PFANHAUSER, W. Die Galvanoplastik. Halle a/S., 1904.

——— Herstellung von Metallgegenstanden auf elektrolytischem Wege und die Elektrogravüre. Halle a/S., 1903.

PHOSPHATE ROCKS OF ARKANSAS. (Arkansas Agricultural Experiment Station. Bulletin No. 74.) Fayetteville, 1902.

LES RICHESSES MINERALES DE LA SERBIE. Paris, 1907.

SOUTH AUSTRALIA. Statistical Register, 1905. Adelaide, 1906.

STORA KOPPARBERGS BERGSLAGS AKTIEBOLAG. Mines and Works in Sweden. Stockholm, 1907.

THORTON, W. W. Laws of Private Corporations of the State of Indiana. Indianapolis, 1902.

UNDEUTSCH, HERMANN. Eine Fallbremse. Altenburg, 1905.

——— Grundsätze für den Bau der Fallbremsen der Bergwerksfördergestelle. Kattowitz, 1906.

U. S. BUREAU OF FOREIGN COMMERCE. Review of the World's Commerce. Washington, 1898.

WOOD, R. D., & Co., PHILADELPHIA. Mond Gas. 1903.

ZEEHAN SCHOOL OF MINES. Annual Report, 1906. Tasmania, 1906.

TRADE CATALOGUES.

AMERICAN BLOWER Co., Detroit, Mich. Bulletin No. 331. "ABC" steel-plate fans. 24 pages.

CARNEGIE STEEL Co., Pittsburg, Pa. Structural beams. 12 pages.

INTERNATIONAL GAS ENGINE Co., Cudahy, Wis. "Ingeco engines;" gas, gasoline, oil, and producer gas driven. 62 pages.

KELLER MFG. Co., Salt Lake City, Utah. Analytical balances for chemists. 15 pages.

MANHATTAN DRILLING Co., New York, N. Y. Dobbins core drills. 20 pages.

STEPHENS-ADAMSON Co., Aurora, Ill. *The Labor Saver*, January and May, 1912, published in the interests of efficiency and economy of production. 24 pages.

SULLIVAN MACHINERY Co., Chicago, Ill.
Bulletin No. 58K. Sullivan duplex air compressors. 16 pages.
Bulletin No. 66F. Sullivan "Lightweight" rock drill. 12 pages.

THAYLOR ENGNG. & MFG. Co., New York, N. Y. Rock crushing machinery. 39 pages.

WESTINGHOUSE ELECTRIC & MFG. Co., East Pittsburg, Pa. Circular No. 109A. Westinghouse turbo-alternators. 35 pages.

United Engineering Society Library.

INVESTIGATION OF THE ECONOMY OF A SIMPLE ENGINE OPERATING WITH STEAM LESS THAN THAT OF ATMOSPHERIC PRESSURE. By R. C. Carpenter. (Gift of Author.)

KAISERLICHE MARINE. Deutsche Seewarte. Jahresbericht über die Tätigkeit der Deutschen Seewarte. 33, 34, 1910, 1911. Hamburg, 1911-1912. (Gift of Annalen der Hydrographie.)

MANUALS OF SAFETY. Yard Practice, Walks and Railings. By Chas. Kirchhoff and W. H. Tolman. New York, 1912. (Gift of American Museum of Safety.)

NATIONAL WATERWAYS COMMISSION. Final Report. Washington, 1912. (Gift of National Waterways Commission.)

SWITZERLAND. Patente Jahres-Katalog XXIII., Jahrgang 1911. Brevets. Catalogue Annuel XXIIIme Année, 1911. Brugg, 1912. (Purchase.)

WHO'S WHO IN AMERICA, 1912-1913. (Vol. VII.) Chicago, 1912. (Purchase.)

MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of May, 1912:

Members.

BARAGER, GEORGE W., Genl. Mgr., Pardee Bros. & Co., Inc., Lattimer Mines, Pa.
BECK, ERICH ALFRED, Met., Goldschmidt Thermit Co.,
90 West St., New York, N. Y.
BROWNING, WILLIAM C., Min. Engr.........Inspiration Copper Co., Miami, Ariz.
DAKE, WALTER M., JR., Milling....................P. O. Box 1386, Goldfield, Nev.
ELLIOTT, ROY HOLLIDAY, Min. Engr...............220 19th St., Pacific Grove, Cal.
GOODRICH, HAROLD B., Geol.....................450 W. 147th St., New York, N. Y.
HOFSTRAND, OSCAR B., Met. Engr..Wallace, Idaho.
HOOVER, WILLIAM MITCHELL, Min. Engr........173 N. Laurel St., Hazleton, Pa.
HUTCHINSON, EDWARD C., Mining........409 Montgomery St., San Francisco, Cal.
JORGENSEN, FRANK F., Min. Engr..........Consolidation Coal Co., Buxton, Iowa.
LELAND, EVERARD, Min. Engr....................Leonard Copper Co., Gleeson, Ariz.
LIBBEY, FAY W., Min. Engr...Wickenburg, Ariz.
MADGE, WILLIAM C., Mech. and Met. Engr.,
62 London Wall, London, E. C., England.
METCALF, FRANK ALBERT, Min. Engr. ....Last Chance Mine, Wardner, Idaho.
MILLARD, H. ALFRED, Mgr. Operating Dept., Breitung & Co., Ltd.,
11 Pine St., New York, N. Y.
MILLIKEN, JOHN T., Cons. Engr., Golden Cycle Min. Co.,
1615 N. Cascade, Colorado Springs, Colo.
NEWTON, HARRY W., Met. Engr...Republic, Wash.
O'CONNOR, EDWARD S., Supt. of Mines....Northwestern Iron Co., Mayville, Wis.
PAGE, EDWIN R., Civ. and Min. Engr.......................................Jodie, W. Va.
PATERSON, ARTHUR W., Prest. and Gen. Mgr., Am. Mines Co., Lewiston, Idaho.
REYNDERS, JOHN V. W., Vice-Prest.....................Penn. Steel Co., Steelton, Pa.
RODDEWIG, GEORGE W., Engr.................Snow Storm Min. Co., Larson, Idaho.
SINGEWALD, JOSEPH T., Geol.......................... 17 W. 29th St., Baltimore, Md.
SMITH, JAMES W., Mgr................................Trenton Iron Co., Trenton, N. J.
SMITH, WEBB, Supt., Kennedy M. & M. Co.................................Martell, Cal.
STEPHEN, WALTER M., Min. Engr...............726 New York Blk., Seattle, Wash.
TINSLEY, ROBERT B., Engr. in charge of Miraflores Locks and Dams,
Corozal, Canal Zone.
TRAUERMAN, CARL J., Min. Engr...Tuscarora, Nev.
WALLOWER, FRANK C., Mine Operator.................................Webb City, Mo.
WEIGALL, HENRY STUART, Min. Engr., Genl. Mgr., Kapsan Mining Concession,
Doten, Korea.
WHITE, ELIJAH E., Prest. and Genl. Mgr., E. E. White Coal Co.,
Glen White, W. Va.
WRAIGHT, EMERT A., Met., Royal School of Mines,
So. Kensington, London, England.
YAMADA, NAOYO, Dir., Mitsui Min. Co.,
23 Nakaroku bancho, Kojimachiku, Tokyo, Japan.
YOUNG, HAYES WILSON, Instructor in Met.................Stanford University, Cal.
YUNGBLUTH, ANDREW J., Mine Accountant..........................Ishpeming, Mich.

Associates.

BARNUM, WILLIAM E., Supt., Blaisdell Coscotitlan Synd.,
Apartado 92, Pachuca, Hid., Mexico.
HOCHCHILD, BERTHOLD....Prest. Am. Metal Co., 52 Broadway, New York, N. Y.
LOEB, CARL M........Vice-Prest. Am. Metal Co., 52 Broadway, New York, N. Y.
PEARCE, SAMUEL LEE, Min. Engr...........Sierra Madre Club., Los Angeles, Cal.

CANDIDATES FOR MEMBERSHIP.

The following persons have been proposed during the month of May, 1912, for election as members of the Institute. Their names are published for the information of members and associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Council, which has the power of final election.

Members.

Enoch Albert Barnard,	Wallace, Ida.
Sydney Alfred Barratt,	Santiago de Cuba, Cuba.
Frederick L. Bergen,	Mullan, Ida.
Albert Broden,	Reading, Pa.
John Yates Brooks,	Ensley, Ala.
Holcombe James Brown,	Buffalo, N. Y.
Curtes R. Burley,	Gem, Ida.
Frederick W. Callaway,	Kellogg, Ida.
John Aloysius Coyle,	Bridgeton, N. J.
Oscar H. Fairchild,	Denver, Colo.
Thomas Ralph Garnier,	South Pasadena, Cal.
Eugene Gifford Grace,	South Bethlehem, Pa.
Warren Earl Greenough,	Wallace, Ida.
John Howe Hall,	High Bridge, N. J.
Eric Crebbin Mackay Heriot,	London, Eng.
Amel Rowles Jayne,	Seattle, Wash.
Sam Paul Lindau,	Kingman, Ariz.
John Lavelle McAllen,	Boston, Mass.
Gibb Machan,	Kellogg, Ida.
George Herbert Morgan,	Globe, Ariz.
Bayard S. Morrow,	Gem, Ida.
George Horace Morse,	Pocahontas, Alba., Canada.
William Clifford Prickett,	Birmingham, Ala.
Stanley Northey Rodda,	Melbourne, Vic., Aust.
Fremont S. Rowe,	Burke, Ida.
Livio Silva,	Shanghai, China.
M. J. Sinclair,	Kellogg, Ida.
William H. Teel,	Wallace, Ida.
Perry Critchly Thomas,	Macdonald, W. Va.
Clifford Redman Wilfley,	Ouray, Colo.
John C. Wood,	Gem, Ida.
Jesse T. Wright,	Wallace, Ida.

Associates.

David Dows,	New York, N. Y.
Marion Eppley,	New York, N. Y.
Harry Graef,	New York, N. Y.
R. G. Holmes,	Spokane, Wash.
Edward Mason Murphy,	Burke, Ida.
Cho Yang,	South Bethlehem, Pa.

CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the month of May, 1912. This list, together with the lists published in *Bulletin* Nos. 63 to 65,

March, April, and May, 1912, and the foregoing list of new members, therefore, supplements the annual list of members corrected to Feb. 1, 1912, and brings it up to the date of June 1, 1912.

ADAMS, WALTER C....La Trinidad, Baces, Durango, Mexico.
ALLEN, ROBERT....P. O. Box 975, Johannesburg, Transvaal, So. Africa.
APPLEGREN, J. O. W....Loope, via Markleeville, Alpine Co., Cal.
ARNOLD, LEO F....719A Quincy St., Brooklyn, N. Y.
ASTLEY, JOHN W....24 King St., W., Toronto, Ont., Canada.
ATKIN, AUSTIN J. R....P. O. Box 6231, Johannesburg, Transvaal, So. Africa.
AUSTIN, ALBERT M., Lawyer, Messumer & Austin, 55 Liberty St., New York, N. Y.
AUSTIN, KENNETH, Cons. Min., Met., and Mech. Engr., P. O. Box 4305, Johannesburg, So. Africa.
BAGGE, N. O....Room 1511, 19 Cedar St., New York, N. Y.
BANCROFT, HOWLAND, Min. Geol....730 Symes Bldg., Denver, Colo.
BARTHOLOMEW, TRACY....General Delivery, San Juan, Porto Rico.
BAYLES, JAMES C....529 East Ave., Easton, Pa.
BENEDICT, W. DE L....19 Cedar St., New York, N. Y.
BETTS, ANSON G....Laurel River Logging Co., Stackhouse, N. C.
BODDINGTON, HENRY D....Royal Colonial Inst., London, W. C., England.
BOYLE, EMMET D., Min. Engr....Virginia City, Nev.
BROWN, WILLIAM N....710 Southern Bldg., Washington, D. C.
BURCH, H. KENYON....314 Central Bldg., Los Angeles, Cal.
CHARTIER, GEORGE M....1144 Title Insurance Bldg., Los Angeles, Cal.
COLLINS, EDGAR A....Commonwealth Mine, Pearce, Ariz.
COOPER, M. D....Care Ellsworth Collieries Co., Ellsworth, Pa.
COREY, W. E....14 Wall St., New York, N. Y.
CORRY, ARTHUR V....P. O. Box 23, Butte, Mont.
DE ARMOND, CHARLES F....519 Metropolis Bank Bldg., San Francisco, Cal.
DONNELLY, THOMAS F....412 W. 149th St., New York, N. Y.
ELLIS, RALPH W., Cons. Min. Engr...1a Nuevo Mexico 6, Mexico City, Mexico.
EMMONS, N. H....659 St. John Ave., Pasadena, Cal.
FERGUSON, HENRY G....U. S. Geological Survey, Washington, D. C.
FIELD, FREDK. M....2343 W. 31st St., Los Angeles, Cal.
GAMBRILL, GEORGE T., JR., Constr. Engr., Woodward Iron Co., Woodward, Ala.
GEIGER, A. W....87 Milk St., Boston, Mass.
GRAHAM, STANLEY N., Room 2, Manning Arcade, 24 King St., W., Toronto, Ont., Canada.
GRESSANG, CHARLES C., Supt. Kelly's Creek Colliery Co., Ward, Kanawha Co., W. Va.
GRIFFITH, WILLIAM V....Bowie, Ariz.
GRILL, CHARLES H....Keddie, Plumas Co., Cal.
HAGEMANN, W., Mgr., Cia. Minera Exploradora y Explotadora de Guanacevi, S. A., Guanacevi, Dur., Mexico.
HAMILTON, CHARLES A., Cia. De Diversidades, S. A., Taviche, Oax., Mexico.
HAMILTON, JOHN W. H., Min. Engr., Hamilton & Hansell, 50 Church St., New York, N. Y.
HANSELL, N. V., Min. Engr., Hamilton & Hansell, 50 Church St., New York, N. Y.
HADDEN, ROBERT W....1807 Harvard Blvd., Los Angeles, Cal.
HARRIS, HAROLD J....Instructed to hold all mail.
HOFECKER, CHARLES A., Mines of Okdagh, Care Messrs. Sealiery & Co., 454 Grande Rue de Pera, Constantinople, Turkey.
JANIN, JOUIS....Solvang, Santa Barbara Co., Cal.
JEFFREYS, GEOFFREY....Apartado 8, Tampico, Tam., Mexico.
KIMBALL, HENRY S....1012 Pierce Bldg., St. Louis, Mo.
KRUTTSCHNITT, JULIUS....1405 Arizona St., El Paso, Texas.
LABARTHE, JULES, Mgr....Mason Valley Mine Co., Thompson, Nev.
LEVENSALER, LEWIS A....Valdez, Alaska.
McKAIG, JOHN S....Care N. J. Zinc Co., Franklin Furnace, N. J.
MALTITZ, EDMUND VON....Dortmund, Germany.
MARSHALL, EMORY M....1210 Eighth St., Des Moines, Ia.
MASTERS, HARRIS K....Ohio Valley Fluor Spar Co., Marion, Ky.
MILLER, D. IRVING....Care C. W. Hunt Co., W. New Brighton, S. I., N. Y.

MOORE, REDICK R., Suriana M. & S. Co., Apartado 1939, Mexico City, Mexico.
MORROW, JOHN T.........Care G. F. Williams, 15 Maiden Lane, New York, N.Y.
MORSE, BRYAN K.........Care H. G. Morse, 340 Madison Ave., New York, N. Y.
MUIR, T. K....................................Rm. 404, 57 Post St., San Francisco, Cal.
NIEDING, BURTON B.........................Kensington Mining Co., Juneau, Alaska.
OLIVER, EDWIN L................................503 Market St., San Francisco, Cal.
OPIE, NICHOLAS................" Marrabinga," Azalea St., Prospect, So. Australia.
PEALE, REMBRANDT....................................70 E. 45th St., New York, N. Y.
PORTER, JOHN J..P. O. Box 664, Staunton, Va.
POWELL, LOUIS W...................................914 Central Bldg., Los Angeles, Cal.
REHFUSS, LOUIS A..Fort Bidwell, Cal.
RICHARDS, F. B., Mgr., Iron Ore and Pig Iron Dept., M. A. Hanna & Co., Cleveland, Ohio.
RYAN, W. A..................Tati Concessions, Ltd., Francistown, Tati, So. Africa.
SAVAGE, ARTHUR E., Castlereagh House, Castlereagh St., Sydney, N.S. W., Aust.
SMITH, E. PERCY......................................15 William St., New York, N. Y.
SMITH, H. DEWITT...Alice, Colo.
STEARNS, I. A..60 S. River St., Wilkes-Barre, Pa.
TAYLOR, HENRY B..............................310 R. A. Long Bldg., Kansas City, Mo.
TRATMAN, E. E. RUSSELL........................1144 Monadnock Bldg., Chicago, Ill.
TRUAX, SEWALL...................................Care W. C. Egan, Highland Park, Ill.
UPTON, G. B...Ravine Road, Clinton, Iowa.
WALKER, WILLIAM L......................422 Wells Fargo Bldg., San Francisco, Cal.
WALLIS, H. BOYD..............................48 Holland Park, W., London, England.
WAY, EDWARD JOHN, Cons. Engr., Anglo-French Exploration Co., Ltd., P. O. Box 2927, Johannesburg, Transvaal, So. Africa.
WEBB, W. MORTON.......................................Box 5, Kingsville, Ont., Canada.
WEED, WALTER H.........................Rm. 1725, 42 Broadway, New York, N. Y.
WHITNEY, JOHN D..Greenville, Cal.
WILSON, ELWOOD J...............................17 Gramercy Park, New York, N. Y.
WOLFF, MARK A.............................618 Pacific Bldg., Vancouver, B. C., Can.
WOLLE, H. C., Gen. Supt...........................Cambria Steel Co., Johnstown, Pa.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address of Record, from which Mail has been Returned.
Baxter, Francis K., Jr.,	423 Wells Fargo Bldg., San Francisco, Cal.
Chamberlain, John R.,	3a de Roma 39, Mexico City, Mexico.
Cook, Edward H.,	Minas Birimoa, S. A , Birimoa, via Canelas, Dur., Mexico.
Danforth, A. H.,	Cotopaxi, Colo.
Fitzgerald, Thomas F. M.,	211 Sharon Bldg., Salt Lake City, Utah.
Furness, James W.,	Coffee, Trinity Co., Cal.
Gmelin, Ernest,	Apartado 57, Aguascalientes, Mexico.
Green, George G.,	133a Vermont Ave., Washington, D. C.
Hamfeldt, George K.,	Care de Wendel & Co., Hayingen, Lothringen, Germany.
Higgins, Edwin,	Randsburg, Cal.
Hollis, R. W.,	Silverton, Colo.
Johnson, Dion L.,	325 Water St., Pittsburg, Pa.
Lampshire, John O.,	Vulture Mine, Wickenburg, Ariz.
Leavell, John H.,	Buffalo Mine, Cobalt, Ont., Canada.
Le Noir, Frank H.,	Box 16, Mt. Bullion, Cal.
McDougall, Wallace D.,	20 Bedford Place, Russell Sq., London, Eng.
Moore, Roy W.,	P. O. Box 48, Velasco, Tex.
Munroe, Martin,	Bengal Coal Co., Murulidih, Mohada, B. N. Ry., Bengal, India.
Nelson, D. W. C.,	Baker City, Ore.
Nobs, Frederick W.,	Negociacion Minera Santa Maria de Guadalupe y Anexas, S. A., Minillas, Zac., Mexico.
Pearson, William R.,	628 W. 114th St., New York, N. Y.
Perks, Harry B.,	419 Board of Trade Bldg., Portland, Ore.
Peterson, Frank,	H. W. Hellman Bldg., Los Angeles, Cal.
Rathborne, Merwyn R. W.,	Amargosa, via Las Vegas, Nev.

Rhew, James W., Cia. Minera y Exploradora de Ventanas, S. A., Ventanas, Dur., Mex.
Sheldon, Waldo, ... Urique, Chih., Mexico.
Short, Frank R., ... Carson City, Nev.
Spicer, Phillip O., ... Care Belgo-Canadian Synd., Kelowna, B. C., Canada.
Thornton, Edward T., ... Apartado 30, Matehuala, S. L. P., Mexico.
Twynam, Henry, . . . O. K. Copper Mine, Cairns, No. Queensland, Australia.
Watson, Ralph W., ... Calloo, Utah, Clifton Mail box.
White, W. P., ... 10 Bernard St., Spokane, Wash.

NECROLOGY.

The deaths of the following members were reported to the Secretary's office during the month of May, 1912:

Date of Election.	Name.	Date of Decease.
1871.	†Oliver, Paul A.,	May 18, 1912.
1881.	**Pullman, J. Wesley,	May 5, 1912.
1893.	*Sjöstedt, Ernst A.,	April 15, 1912.
1906.	*Smart, George O.,	November 29, 1911.
1905.	*Stevens, Horace J.,	April 22, 1912.

BIOGRAPHICAL NOTICES.

Torbert Coryell was born at Lambertville, N. J., Nov. 16, 1845. He was the son of Martin Coryell, one of the founders and the first Secretary of the American Institute of Mining Engineers, and also one of the pioneer engineers who laid the foundations of American coal-mining and canal- and railway-transportation. During the childhood of Torbert Coryell, his parents removed for a time to Hazleton, Pa., where, at an unusually early age, he assisted his father in the work of developing the anthracite-mines of that district. Meanwhile, however, he had attended the well-known school at Lawrenceville, N. J. Later, he was connected with his uncle, Miers Coryell, in the business of transportation by land and sea, and, in pursuance of that business, made several trips to southern waters. He was also associated for a time with the Morgan iron-works in New York, and, at a later period, entered the employ of the Laflin & Rand Powder Co., subsequently becoming for a time Superintendent of Gen. Oliver's powder-mills.

In 1877, Mr. Coryell made a trip to South America in one of the vessels of the Cromwell Steamship Co., of which his uncle was then at the head. This trip included a stop at Aspinwall (now Colon), where he made many friends; and his experience was impressed upon those of us who, in 1910, attended with him the Canal Zone meeting of the Institute, by his encounters with some of his old friends still surviving, and his stories of former times on the Isthmus.

Mr. Coryell became a member of the Institute in 1883, and maintained until death a loyal interest in its proceedings and its welfare, frequently taking part in its meetings and the excursions connected therewith.

Of late, he resided finally at Lambertville, of which he was for eight years Mayor—in fact, until he refused to serve longer. He was President of both the Lambertville and the Bound Brook water-

** Life Member. * Member. † Associate.

companies, and it is acknowledged that the city owes its pure and abundant water-supply at all seasons to his tireless personal interest and vigilant supervision. Other positions of trust held by him bore witness of the confidence reposed in him by his fellow-citizens.

Many of us will personally miss hereafter his cordial, friendly presence. R. W. R.

Harry Robert Hall was born Jan. 16, 1868, at Mogadore, O. After a preliminary education in the schools of Cleveland, O., he entered the Ohio State University, from which he was graduated in 1889 as Engineer of Mines. Having given special attention to analytical chemistry, he sought, and easily found, occupation in that line. In 1889, he was assistant chemist of the Middleport steel plant; in 1890, chemist of the Carbon Iron & Steel Co., at Parryville, Pa.; in 1891, chemist of the Crane Iron Co., Catasauqua, Pa. But, as I have had occasion to observe already, in reviewing the careers of other members in this field, the chemist is, in the new era of the metallurgy of iron and steel, both arbiter of theory and director of practice; and, for a young man otherwise competent to command, conciliate, and advise, the gate of promotion opens through the chemical laboratory. So it is not surprising that Mr. Hall returned in 1892 as Superintendent, to the Carbon Iron & Steel Co., of which he had been chemist two years before. This position he retained for six years. In 1899, he became Assistant General Manager of the Dunbar Furnace Co., of Pa., and in the following year Division Superintendent of the Virginia Iron, Coal & Coke Co., in charge of its furnaces at Middlesboro, Ky. In 1901, he was connected as engineer with the Wellman, Seaver & Morgan Co., of Pittsburg, Pa., and Cleveland. O.; in 1902 and 1903, he had charge of the blast-furnaces o. the Algoma Steel Co.; and in 1904 and 1905, he was furnace-manager of the Delaware & Hudson Co.'s works at Standish, N. Y. In 1906, he was called to superintend the furnaces of the Crane Iron Co., at Catasauqua, Pa., where he had been chemist fifteen years before. In this position, which he occupied until he died, Mr. Hall won much praise for the technical ability of his management.

He became a member of the Institute in 1891, and contributed to its *Transactions* a valuable paper on The Use of High Percentages of Fine Ore in a Charcoal Blast-Furnace (*Trans.*, xxxvi., 360). He was actively interested in social, charitable, and church work at Catasauqua, and enjoyed the confidence and esteem of his fellow-citizens, his employers, and his workmen.

Mr. Hall died Dec. 10, 1911, after a surgical operation, at the German Hospital, in Philadelphia, leaving a widow and two young children, whose bereavement elicits the sympathy of innumerable friends, while it is mourned also by the wider professional circle of those who lament the sudden termination of an honorable, useful, and promising career. R. W. R.

Daniel B. Kane was born Dec. 3, 1861, at Muskegon, Mich., and was brought by his parents in 1866 to Salt Lake City, Utah, where he received his preliminary education. He never had the benefit of systematic technical instruction; but, surrounded as he was at Salt Lake City with active and impressive mining-operations, he

gained a practical knowledge of that art through actual labor in it. When, in 1906, he was proposed for membership in the Institute, he had already been a miner and prospector; constructing mechanic at the Blackbird mines, Utah; Superintendent of the Monolith mines, Idaho, and the Copper Mountain mines, Utah; Manager of the St. Peter's mines, Oregon, and the Oro Cache mines, Idaho; and Superintendent of the Kittie Burton mines, in Idaho. These positions are here named in their presumable chronological order.

In 1904, he was engaged in Salt Lake City by the Cerro de Pasco Mining Co. as a mining engineer and surveyor, and, at Cerro de Pasco, Peru, he spent about three years in the service of that company. Mr. Harlan S. Emlaw, under whom he served, writes concerning him:

> "He was a very quiet, unassuming man, intensely loyal to his employers, and ready at all times to do all of his own work and part of some other fellow's."

A pithy and pregnant summary, which makes one long for further particulars concerning a man who could be thus characterized!

After finishing his work for the Cerro de Pasco Co., Mr. Kane was employed for about two years by Mr. Frank Klepetko in various expert investigations. It is reported also that he was for some time similarly employed by Mr. F. S. Pearson.

In November, 1910, he returned to Peru, to resume his connection with the Cerro de Pasco Co.; but before he could begin his work, he was stricken with paralysis, and died, Jan. 1, 1912, in the hospital at Callao. R. W. R.

J. Wesley Pullman, son of John and Mary (Cooper) Pullman, was born Dec. 16, 1839, in the city of New York. His mother was a niece of Peter Cooper; and this relationship influenced, to a considerable extent, his business career. Graduated in 1858 as B. S. from the New York Free Academy, now the College of the City of New York (from which he afterwards received the degree of M. S., "Master of Science"), he spent a few months in teaching, and then went, in March, 1859, to the Cooper Iron Works, Phillipsburg, N. J., first as a clerical employee, and later as Assistant Superintendent, under the eminent ironmaster, Joseph Kent. (It was at these works, known later under the name of the Andover Iron Co., that the first experimental Bessemer converter in America was installed in 1856, within sixty days after the reading in England of Bessemer's famous paper. See *Trans.*, xix., 516, and xxxiv., 190). He remained at these works until October, 1864, when he accepted the management of the charcoal-iron blast-furnaces of the Collins Iron Co., at Marquette, Mich. Since Cooper & Hewitt, the business successors of Peter Cooper, were interested in the iron-mines of the Marquette region, this change, doubtless, did not sever his connection with them. He retained his position with the Collins Iron Co. until Jan., 1866, when he returned to the East, to become, for a couple of years, Secretary of the Trenton Iron Co. (owned by Cooper & Hewitt), and the Philadelphia sales-agent of the Andover Iron Co. The latter place he held for twenty years. In 1887, he established himself in Philadelphia as a commission-merchant for iron-ore, iron, and steel—a business for which he was qualified by business and

technical experience, and which he conducted with success until his retirement from it in 1907.

During this period, however, he was incidentally connected with other important enterprises, mostly allied in some way to the Andover Iron Co. and its owners. Some of these relations he continued to fill, even after his retirement. From 1869 to the day of his death, he was nominally Treasurer, but actually Manager, of the Chester Iron Co., operating sundry iron-mines in Morris county, N. J. As Secretary and Treasurer of the Hibernia Mine R. R. Co., he was influential in the management of that remarkably productive operation. He was also interested in the West Point Furnace Co., which operated a blast-furnace at Cold Spring, on the Hudson. This enterprise illustrated some of the important features of old-fashioned blast-furnace practice. At one time, if I remember correctly, it did much for the introduction of "mineral wool," prepared from blast-furnace slag, as a non-conductor of heat and sound.

But all these undertakings, based upon the utilization of New Jersey magnetites—including those which included the preparation of the ore by roasting or magnetic or other concentration—had to meet the fierce competition of the relatively rich, pure, and cheap ores of Lake Superior. Some of them have survived that competition. Others were suspended in view of it. But the iron-ores are still there, and are beginning already to be again appreciated as an available raw material. Meanwhile, it is noteworthy that Mr. Pullman, who served these enterprises so faithfully, was himself influential in that introduction of Lake Superior ores into Eastern markets which was, for a time, fatal to many of them.

He became a member of the Institute in 1881, and retained to the end a lively interest in its success. In 1885, he contributed a paper on "The Product of the Hibernia Mine, N. J." (*Trans.*, xiv., 904), which contains much information, historical and technical, of the kind which is so easily lost, so hard to recover, and often so precious.

In 1873, he married Julia, the eldest daughter of Mr. J. C. Kent, who survives him, together with another daughter and two sons. He died May 5, 1912, at Cheltenham, Montgomery county, Pa., which had been his home since 1878. Only a few days before, he called at this office, and spent some time with me in the renewal of the old memories and associations so dear to us both. That interview furnished no sign of failure or change in his intelligence, sympathy, or vigor. Another of the Old Guard has dropped from the ranks. We who remain can only march solemnly, with weapons reversed, to the cadence of the funeral march; present arms; fire the farewell salute;—and then return at "quick-step" to our posts of duty. R. W. R.

Ernst A. Sjöstedt was born in 1852, at Hjo, Sweden, and after a preliminary education at Skara, entered the Stockholm School of Mines, where he was graduated in 1876. He went immediately to the Le Creusot works in France, but soon came to the United States, to begin, as assistant chemist of the Bethlehem Steel Co., under John Fritz, a distinguished and useful professional career of thirty-six years, the successive steps of which can only be barely outlined

in this brief notice. He became associated for a time with Mr. John Birkinbine, the eminent mining and mechanical engineer, and then, as chemist of the Katahdin iron-works, Maine, carried on an important series of experiments in the desulphurization by roasting of sulphurous iron-ores, which resulted in the employment at those works of the Westman kiln.

His next position was that of chemist of the Malleable Iron Fittings Co., Brantford, Conn., which he left, after a short period, to take charge of the blast-furnaces of the Shelby iron-works, Alabama, and later to be general manager of the Cherokee iron-works, at Cedar Town, Georgia. In these two positions he spent about five years, so that some nine years of his professional career had elapsed when, in 1885, he was recalled as General Superintendent to the Katahdin iron-works, where he had been chemist seven years before. I may here repeat what I have said on a preceding page in my notice of Mr. Hall—namely, that, under the new metallurgical practice in iron and steel, the laboratory is, for competent aspirants, the door of promotion. The chemist, especially when he is also acquainted with mechanical engineering, is the heir apparent to the throne. Mr. Sjöstedt remained as General Superintendent at Katahdin for five years, during which period he rebuilt the furnaces of the company. About 1891, he established, in Nova Scotia, the Pictou Charcoal Iron Co., of which he was for the next six years the manager. During this period, the year 1893 was made notable by the Chicago International Exposition, and the holding, in Chicago, of the International Engineering Congress, of which the American Institute of Mining Engineers conducted the proceedings, and published the papers and discussions, of two departments—those of mining and metallurgy. This strenuous year, involving the publication of two volumes of *Transactions*, instead of one, and double work on the part of the officers and employees of the Institute, brought abundant compensation in the confirmation of its national and international standing, and secured for it the support of many new members, among whom was Mr. Sjöstedt, who became a member in 1893.

Members acquainted with the history of iron metallurgy will not fail to read between the lines of the foregoing narrative that for more than twenty years this zealous and brilliant expert devoted himself chiefly to the maintenance, improvement, and prolongation of an industry doomed to decline—namely, the manufacture of charcoal-iron. Not only the progressive failure (or, what is economically the same thing, the ever-growing price) of the fuel-supply, but also the encroachment of other pig-irons of special formula, and low-carbon steels, upon the special field of charcoal pig-iron, gave warning of this fate. But a man who has become thoroughly expert and successful in one department of applied science cannot be rendered useless by the supersedure of his specialty. He will certainly find recognition and reward in some one of the new departments created by progress, and requiring similar knowledge and proved efficiency.

In 1897, Mr. Sjöstedt established himself as a consulting metallurgical engineer in Montreal, making a specialty of designing roasting-furnaces and gas-producers, and utilizing peat and refuse. This was the natural step suggested by the relative failure of the charcoal fuel-supply, and the needs of establishments which could

not command cheap coal. The gas-producer, utilizing carbonaceous waste material of all kinds, is the evident refuge of industries thus situated; and the rapidly extending use of the gas-producer for other reasons, including its inherent technical efficiency and economy, has been largely due to the example of those who had to choose between gaseous fuel and none at all.

Two years later, Mr. Sjöstedt became the chief metallurgist of the company organized in Canada, with headquarters at Sault Ste. Marie, Ontario, which comprised many different metallurgical enterprises, some of which were not profitable, and all of which, taken together, were too much for the capital to carry. Through the checkered financial history of the enterprise, culminating in the organization of the Lake Superior Power Co., Mr. Sjöstedt retained his place as adviser, valued by directors and receivers alike. He seems to have been specially concerned with the nickeliferous pyritic deposits owned by the corporation in the Sudbury district; and he made a thorough study of these ores, with the view of devising a method of direct smelting, which would produce a nickeliferous pig-iron, more suitable (as well as more economical) for the manufacture of nickel-steels than the nickel-alloy now added for that purpose to the bath of steel, and not certain of a perfectly uniform distribution through the ingot. His method would also utilize the iron of the ores, which is slagged away in the usual process of treating them for nickel. Of course, the trouble with such a process was the sulphur in the ore, which, even after the best roasting, amounted to from 1.5 to 3 per cent.—far too much for the direct smelting which he contemplated.

In the face of this difficulty, Mr. Sjöstedt turned for relief to electric smelting—the greatest metallurgical improvement thus far credited to the twentieth century—in which his countrymen have gloriously taken the lead, while all nations eagerly watched and cautiously followed them. Without practical experience in electro-metallurgy, and without suitable apparatus, he constructed an electric furnace, from which he managed to produce a nickel-iron pig, containing more than 4 per cent. of nickel, about 1.5 of copper, and only 0.010 of sulphur. I take these figures from the enthusiastic private letter of a friend; but I think they have been already publicly reported; and, at any rate, they indicate something new and noteworthy.

From the same source I learn that, during his connection with the Lake Superior corporation, Mr. Sjöstedt built the reduction-works and the water-gas plant at the Sault, and introduced (and patented) the MacDougal-Sjöstedt sulphide roaster, the Sjöstedt-James electrolytic copper and nickel process, and also the Sjöstedt Electric smelting process.

From the day of these experiments to the day of his death, he was a thorough believer in the possibilities of the electric furnace; and it was partly through his influence (due to the high reputation which he had earned as an honest and competent expert) that the Canadian government decided to make, during the winter of 1905–6, at Sault Ste. Marie, experiments in the manufacture of pig-iron by electric smelting, which confirmed, in a larger and more modern furnace, the results obtained by him. At the conclusion of these experiments, the plant was taken over by the Lake Superior cor-

poration, and Mr. Sjöstedt produced from it, during four months' operation, about 200 tons of nickeliferous pig, containing an average of less than 0.015 per cent. of sulphur.

For several years preceding and following this test, he pursued enthusiastically the novel art of electric smelting, the development of which promised so much to Canada. There are, in fact, at this time, three regions in the world which may expect to be most highly advantaged by this great metallurgical improvement: the Scandinavian Peninsula, the Empire of Japan, and the eastern part of the Dominion of Canada. All three are rich in mineral resources, relatively poor in mineral fuel, and abundantly supplied with water-power. It is no wonder, therefore, that the government of Canada, recognizing the combined enthusiasm and experience of Mr. Sjöstedt, united with the Lake Superior corporation to send him to Europe, last January, for the study of what had been done by other nations in this new, revolutionary, and promising art.

Mr. Sjöstedt contributed many articles to technical journals, among which may be mentioned a paper on the utilization of peat, printed in *The Mineral Industry* for 1899, and a description of a new charcoal retort-plant of the Algoma Steel Co., which appeared in *The Iron Age*, Jan. 28, 1904. On Feb. 18, 1904, the same journal described and illustrated the furnace which he had designed for the direct production of ferro-nickel from pyrrhotite.

Alas! Must I always end such a story of struggle, progress, and triumph with a tragedy? Our profession leads us often into strange, wild countries, and exposes us to the risk of violent death; but this time we are mourners with a host of others, among whom there is no distinction of class or occupation. Our brother, returning by the *Titanic*, and bearing the fruits of his intelligent and skillful quest, went down to his death on April 15, 1912, with other victims of that awful disaster, proving himself, at the last, something greater than a great expert—to wit, a man! We mourn the loss which science and industry have sustained; and we share the sorrow of that widow and daughter who may well deem their loss still greater; but, above all, we rejoice in the useful and honorable life which has been thus crowned with a heroic death. R.W. R.

George James Wanless was born April 12, 1855, at St. Catharine's, Quebec, Canada. His parents moved, in 1856, to Mendota, Ill., and in 1859 to Denver, Colo., where he went to school until his twelfth year, when he entered Emanuel Hall, Chicago, Ill., for a course preparatory to college. He was subsequently appointed as a cadet in the U. S. Naval Academy, but resigned from the Navy to take a course of study at the Colorado School of Mines (then at Colorado Springs, before the establishment of the State School at Golden). After his graduation, in 1880, he conducted, for a while, a private assay-office at Idaho Springs, Colo., and afterwards served as assayer and chemist at Socorro, and in the Toledo smelter at Kelly Camp, N. M. In 1889, he became the representative and ore-purchasing agent, at Jimenez, Chihuahua, for the St. Louis Smelting & Refining Co.; in 1894, agent and ore-buyer, at Hermosillo, Sonora, of the Cons. Kansas City S. & R. Co., which operated smelting-works at El Paso, Tex. Later, he was stationed in the service of the same company, at El Paso; and, still later, became ore-purchasing agent

for Mexico of the American Smelting & Refining Co., into which the Kansas City and other companies had been merged by purchase. I need hardly say that the work of an ore-buying agent is one which involves, to a serious degree, the success of a smelting-enterprise, and requires a knowledge of ores, commercial conditions, and men, not always found in one and the same person. The circumstance that Mr. Wanless was retained in that position, and even advanced to a larger field, by a new administration, says much for his proved ability and fidelity.

He joined the Institute in 1902. In Nov., 1911, he became ill; and he died Mar. 3, 1912, at his home in El Paso, Tex.

R. W. R.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Progress in Roll-Crushing.

BY C. Q. PAYNE, NEW YORK, N. Y.

(New York Meeting, February, 1912.)

THE art of crushing ores and other materials by means of rolls is a comparatively recent one. While the first record of rolls using iron crushing-surfaces dates back to the year 1806, when they were employed in Cornwall, their principal development has taken place during the last 30 years.

To Stephen R. Krom belongs the credit of the pioneer in introducing the belted high-speed roll, which has had its origin and a marked development in this country. His notable contribution to the art was in the use of a single bed-plate or frame supporting the roll-shafts, and to which levers holding the movable roll-bearings were pivoted. He also made use of steel tension-rods to support the crushing-strains, and of hammered-steel tires for the crushing-surfaces. These changes brought the design of crushing-rolls to a high level.

Following closely thereon, about 1885, W. R. Eckart conceived the idea of the swivel or ball-and-socket support for the roll-shaft bearings. This is an excellent mechanical conception, especially for bearings held against a spring pressure, and while it may not be necessary for all types of rolls, yet it has been quite generally adopted by other roll-designers, and illustrates the refinement which roll-construction has now reached.

Other engineers, as for example, Argall, Vezin, Roger, and Sturtevant, to mention only a few among many, have also given the closest attention to the various details of rolls, such as the frame, springs, bearings, and shafts, and have developed many novel and original designs. It has remained, however, for the boldness and originality of Mr. Edison to extend the field of crushing-rolls in two new directions, and to cause them to exercise new functions. In developing crushing-machinery for his Portland cement works, Mr. Edison constructed "giant" rolls, having a diameter of 6 ft. and a length of face of 7 ft.

With these he was not only able to challenge the long-established position of the jaw- and the gyratory crushers as primary crushers, but even to leave them well in the rear. By means of projecting knobs on the roll-surfaces he utilized the stored energy of the revolving rolls, and was able to shatter masses of rock of so huge a size that they could not otherwise be made to enter the rolls, thus saving the expense of block-holing and sledging, which is usually charged to quarrying. This work has had successful applications in crushing limestone rock, and there remain also possibilities of the extension of this new use of rolls to rocks of a still harder nature.

In going to the other extreme of size-reduction, Mr. Edison has also utilized rolls in pulverizing cement-rock in his work. For this purpose, rolls with sectional, corrugated, chilled-iron shells 30 in. in diameter and 8 in. face, are provided with shafts 18 in. in diameter, and are forced together with a spring pressure of 100 tons. The feed-material, which has passed a 0.75-in. screen-opening, is thus reduced in a single operation to a size at which 94 per cent. passes 100-mesh screen, at the rate of 60 tons per hour. This use of rolls carries the principle of choke-crushing to so extreme a limit as to involve practically a new function. It would appear at first sight, however, that there is less profit-margin for rolls in pulverizing than in mass-reduction, and only a close comparison of the final products obtained and the respective costs per ton can determine the relative economy of rolls for pulverizing when compared with the tube-mill and other types of grinding-apparatus.

Rolls for Coarse Crushing.

Irrespective of the part which rolls may play in the future in their relation to the two extreme limits of size-reduction, there is no doubt that they have achieved for themselves a secure position in crushing products of intermediate sizes. This is partly due to their large capacity and low cost of operation. It is also due to the fact of their mechanical simplicity, which involves the principle of the toggle-lever in overcoming crushing-strains exerted by particles brought within the angle of nip of their surfaces. Since their revolving masses also serve to absorb their own "peak-loads" when properly fed, a moderate and fairly uniform application of driving-power is able to accomplish a

considerable amount of effective work in splitting and shattering rock-fragments.

Perhaps the most distinctive advantage of rolls is that their construction permits them to apply the principle of "arrested crushing" to a greater range of sizes than is possible with any other type of crushing-apparatus. The crushing-pressure exerted by the opposing roll-surfaces during the angle of nip is instantly released and ceases when the rock-fragments reach the horizontal diameter of the rolls, where the open space between them permits the material to be discharged. Roll-crushing thus permits most careful and accurate stage-reduction within a wide range of sizes, and avoids pulverizing and sliming an undue amount of the softer minerals of an ore, in crushing it to the size at which they will unlock sufficiently from the surrounding gangue to permit their concentration to take place. For those ores, therefore, which require concentration, the use of rolls in preparing them for jigs, shaking-tables, or magnetic separators has become almost the universal practice. This applies to many iron-, copper-, lead-, and zinc-ores. Gold- and certain silver-ores, both those which require concentration and those which do not, are in a class by themselves, since usually their values can be extracted without essential relation to the granular condition of the crushed product.

The modern tendency to reduce milling-costs by increasing the mill-capacity has demanded a greater duty from rolls than ever before, and in the larger mills rolls are now employed from 36 up to 54 in. in diameter, and from 15 to 28 in. width of face. Such rolls are used mainly for coarse crushing; that is, they take the product from the jaw- or the gyratory crusher, from 1.5 to 2.5 in. in size, and reduce it to about 0.5 in. These coarse or No. 1 rolls are then followed by other rolls set closer together for finer crushing, and possibly by others which re-crush certain middlings products obtained in the process of ore-treatment, or even tailings, dependent upon the nature of the ore and its association. Rolls of this general character require massive construction and excellent workmanship. Rolled-steel tires can now be obtained up to 54 in. in diameter. Special hard steels, such as chrome- and manganese-steels, are also used for certain ores, either in the form

of tires or of plates bolted to a central mandrel. In this way the life of the crushing-surfaces has been much prolonged.

Marked progress has thus been made within recent years in the field of coarse crushing by means of rolls, in response to the greater demands of modern mill-practice, and this progress has been largely brought about by increasing the dimensions of the rolls and adopting a more massive construction, as well as a better design, combined with a wider choice of steel adapted to different ore-requirements than has heretofore been available.

Rolls for Fine Granulation.

On the other hand, it must be admitted that up to the present time rolls designed for fine crushing, where the ore-requirements demand a maximum granulating effect and a minimum pulverizing or sliming effect upon the crushed product, have made little progress compared with rolls designed for coarse crushing. In fact, rolls, as heretofore designed, can hardly be said to have held their own; and since little assurance of their satisfactory operation can be had in connection with an ore which must be reduced to pass a 20- or 30-mesh screen while retaining the crushed material in a granular condition, rolls have been assailed on all sides by various types of ball-mills and other pulverizing-apparatus which claim to accomplish the function of granulating an ore successfully, but usually by means of some reduction in the time during which the pulverizing effect takes place. While there may be an overlapping territory at the limit of fine granulation where pulverizing-apparatus may be so adjusted as to perform the function of approximate granulation with sufficient success to make their use advisable, yet it is clear that a crushing-force exerted upon material placed between walls which do not touch when at their minimum distance apart, must produce a distinctly better granulated product than when it is crushed between walls which are brought into physical contact with a grinding-pressure.

With the presumption of advantage thus on the side of rolls, even down to the finest sizes, the fact remains that heretofore rolls have proved unsatisfactory and inefficient, from lack of control over the granulating action as the roll-faces wear, and also from their small capacity.

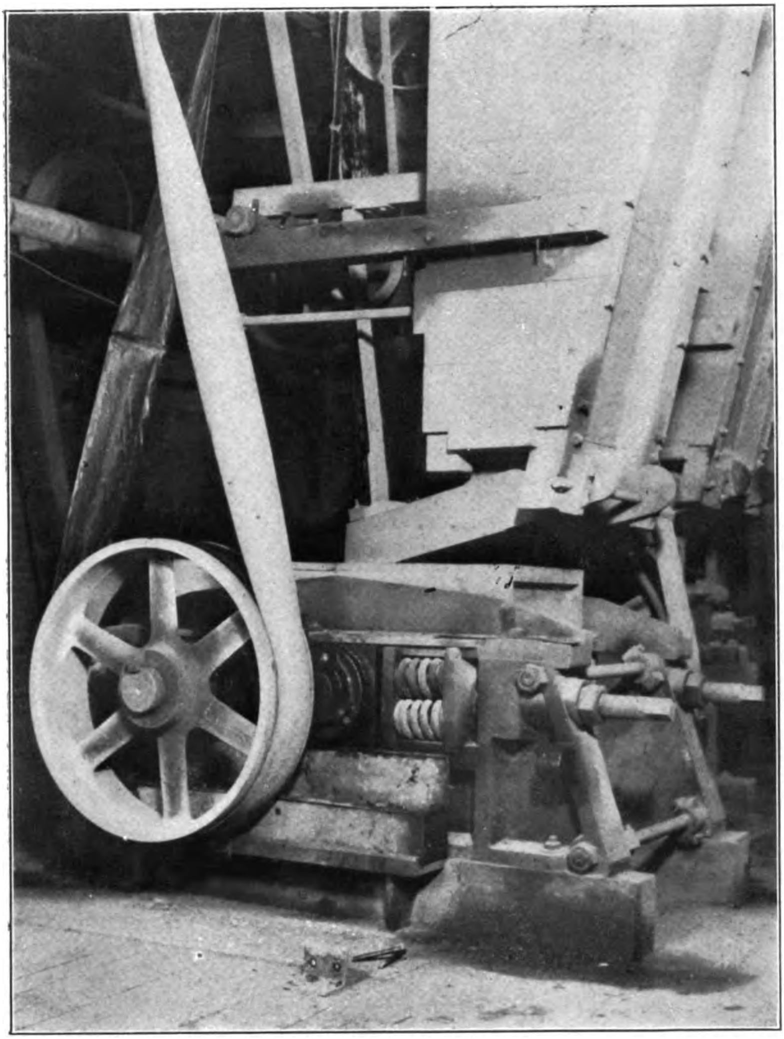


FIG. 1.—SIDE-VIEW OF 18- BY 12-IN. FRAZEE ROLLS.

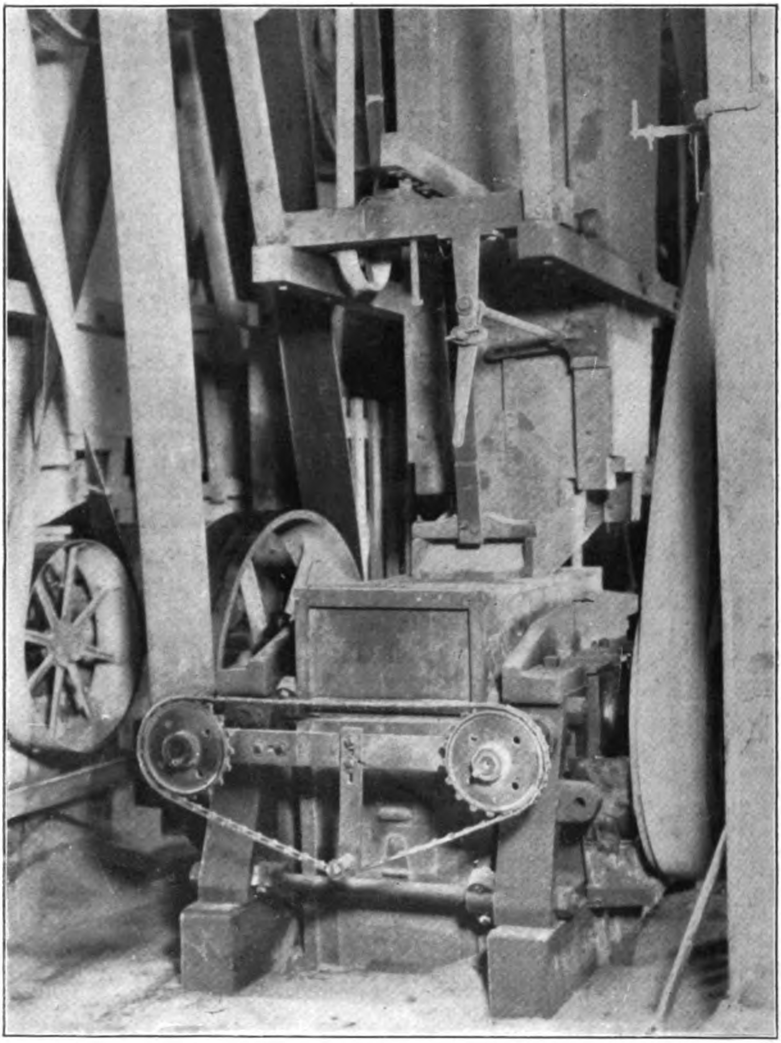


FIG. 2.—END-VIEW OF 18- BY 12-IN. FRAZEE ROLLS.

In looking more closely into the cause of this inefficiency, it is evident that the effect of the irregular wear of the roll-faces becomes a more serious matter in fine crushing than in coarse crushing, for the reason that in the former, since the faces must be brought quite close together, the ratio of the sectional area due to irregular wear to the total areal opening between the rolls is greater than in the latter case. Hence any ridging, grooving, or corrugating of the roll-faces permits a considerable proportion of the particles in the feed-stream which enter the depressions to pass between the rolls without being crushed. This reduces the capacity of the rolls, measured by the amount of "under-size" or finished product obtained. Another difficulty arising from irregular wear of the roll-faces is due to the fact that when out of parallelism rolls tend to exert a certain component of the crushing-pressure at right angles to the diameter of the rolls, or in the direction of the axes of their shafts. This produces an end-thrust upon the roll-shafts, which, transmitted by means of collars to their bearings, causes them to heat and the shafts to cut, thus absorbing power wastefully, and still further reducing the crushing-efficiency as measured by the power consumed to operate the rolls in relation to the amount of finished product obtained.

Rolls used for fine crushing thus show a decreasing efficiency in proportion to the wear of their roll-faces until a point is reached where it becomes necessary to stop the crushing-operation, and to restore the faces by chipping, grinding, or machining them until their surfaces are parallel. This involves loss of time and of mill-capacity, besides expense and a wasteful use of the roll-shells.

While a certain amount of choke-crushing is usually advisable in fine crushing, in order to offset some loss of capacity, the best results can only be obtained, where the prime object is to granulate an ore, when the roll-faces are maintained parallel, and when the feed consists of sized material in order to avoid packing and pulverizing it in passing it between the rolls. It seems clear from the above considerations that further advance in the art of fine granulation by means of rolls can only be expected by means of certain refinements of function whereby the roll-faces can be maintained parallel while they undergo wear.

Frazee Rolls.

Having had the problem of fine granulation in mind for some time past in its relation to the treatment of certain classes of ores, I have been gratified to find in a recent design of rolls by

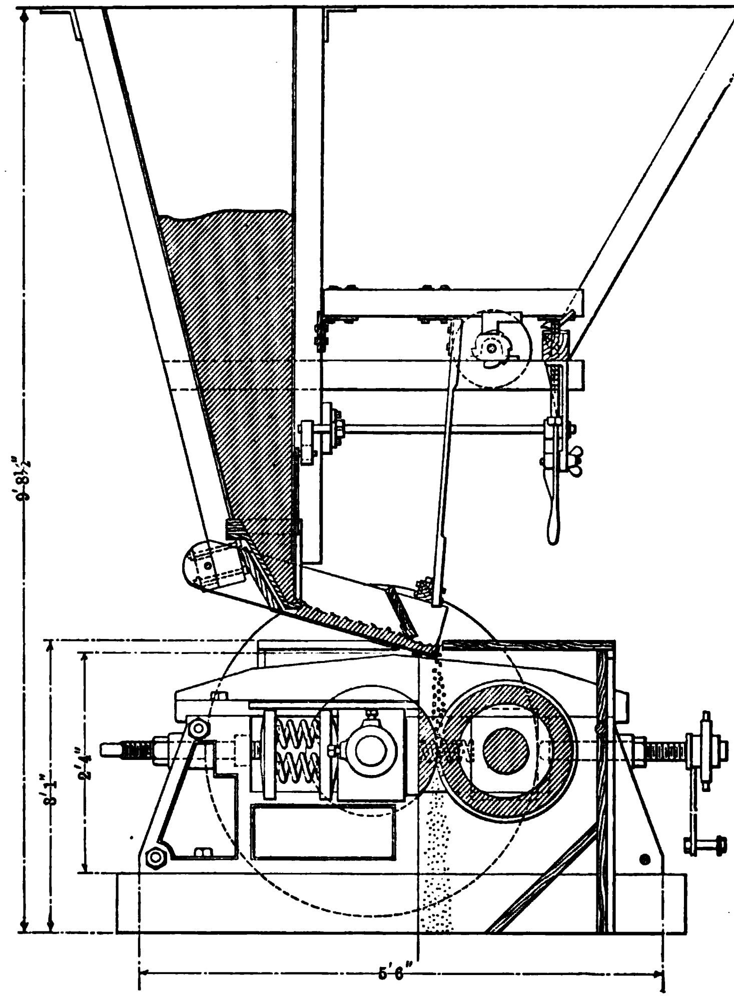


FIG. 3.—18- BY 12-IN. FRAZEE CRUSHING-ROLLS. PART SECTIONAL SIDE-ELEVATION ALONG LINES D, E, F OF FIG. 4.

J. S. Frazee, of Brooklyn, N. Y., that he has completely overcome the obstacles which have heretofore prevented the satisfactory operation of rolls when used for fine crushing, and when a granulated product is required.

Mr. Frazee has given me the privilege of presenting a brief account of his rolls to the Institute; and as I believe they are not generally known, I take pleasure in doing this, in the confident belief that they mark an important step in the advance of the art of roll-crushing.

Figs. 1 and 2 show a side and an end view of a pair of 18- by 12-in. rolls. It will be seen from Figs. 3 and 4, which show the same rolls in plan and part sectional elevation, that the bearings of the roll shafts are supported in side-frames. These are of cast-iron, without tension-rods, and are held together by

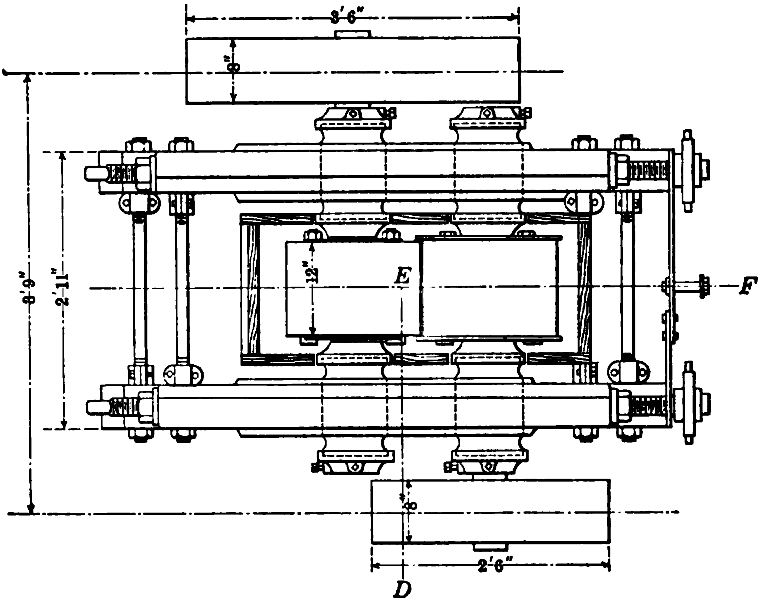


FIG. 4.—PLAN BELOW ROLL-HOUSING.

stay-bolts and lock-nuts to permit the width between the frames to be slightly adjusted, if necessary, when the rolls are in place. This construction has certain advantages for fine crushing over the single bed-plate or frame. It is lighter, less expensive, and permits the rolls to be completely boxed in by means of a wooden housing. This is hoppered at the bottom, and is connected with an exhaust air-pipe, through which the fine dust is drawn by means of a fan, thus keeping the mill-space free from dust. The bearings are of the solid type, lined with babbitt, and each provided with dust-caps at each end. All four are movable in

the guides provided for them in the frames. Two of the bearings are held against a spring pressure, and the other two against screw adjusting-bolts, for the purpose of regulating and controlling the space between the roll-faces. These adjusting-bolts are provided with sprocket-wheels and an endless link chain, which is kept taut by means of a small idler between them. By inserting a long-handled spanner in openings in either of the sprocket-wheels, the adjusting-screws can be moved in exact unison in varying the position of the roll-space. This feature has been found a very convenient one, as it permits close and accurate adjustments of the gap between the roll-faces to be made while the rolls are running.

One of the essential features of Mr. Frazee's design consists, as shown in the illustrations, in making one roll-shell longer than the other, so as to permit flanges to form on it, between which the shorter roll revolves, with a slight clearance. The rolls are fed from a hopper, which is supported independently of the roll-frame, and in such a position as not to interfere with the removal of the rolls. The lower end of the hopper is made of cast-iron, and is provided with a gate, which is operated by means of a shaft and levers, so that it can be controlled from the forward end of the roll-frame. A feed-tray is placed below the hopper so as to convey the material to be crushed from the hopper-gate to the space between the rolls. This feed-tray is supported at the back of the hopper by a pivot-bolt, which allows it to rotate slightly, and at the front end by means of a wooden connecting-rod to a horizontal arm flexibly connected to a support at the front of the hopper. When the front end of the arm is raised by the teeth of the revolving cam below it, the discharge end of the feed-tray is caused to rise and fall with a jarring or bumping motion. This causes the material in the feed-tray to be carried forward and to be discharged in a steady stream over the angle-iron which forms a lip or dam at the extreme edge of the tray. The bottom of the feed-tray is made of sheet-steel to permit the material to slide freely. The amount of motion imparted to the end of the feed-tray can be varied by means of an adjusting screw-bolt, which regulates the height of the drop of the horizontal arm, and thereby also the effect of the bumping action upon the feed. A small lever at one side of the adjusting-bolt permits the horizontal arm to be raised above the

level of the cam, and in this way the feed can be instantly stopped and started.

It has been a common experience that as rolls are usually fed, even when great care is taken to secure a feed-sheet of uniform thickness, the roll-shells will groove and wear more rapidly at their centers than at their ends. This is frequently caused by a difference in the rate of flow of the feed-stream, owing to friction of the sides of the chute or spout leading from the hopper to the rolls. Another cause of greater wear of the central portion of the roll-shells is the greater mobility of the feed-stream in certain directions than in others, when subjected to a crushing pressure. This difference in mobility causes a difference in the amount of abrasion, and it shows itself by the cupping, grooving, or corrugating of the roll-faces along the center, and by ridging at the edges of the roll-shell. Mr. Frazee has found that the difficulty of irregular wear of the roll-shells can be entirely overcome by a close control over the sectional shape and area of the feed-stream, and by feeding a greater amount of material along the sides of the roll-faces than at their centers.

As shown more clearly on a larger scale in Figs. 5 and 6, the projecting side of the angle-iron which forms the lip of the feed-tray is cut down at its two ends, so as to slope gradually towards the ends, leaving its full height only at the center. In this way the feed-stream passing over the lip or dam is made thicker at the ends than at its center. Furthermore, to regulate the flow and upper contour of the feed-stream, as well as the lower, a guide-plate, which is usually hinged to the sides of the feed-tray, is allowed to rest upon the surface of the feed-stream. This is provided with a wearing-plate at its lower edge, and is so beveled at its two ends as to permit a somewhat greater freedom of flow of the feed-stream at its edges than at its center. The shaded area in Fig. 6 shows the approximate cross-section of the feed-stream, which is adjusted to secure an equal abrading effect across the entire width of the roll-faces, and thus to maintain them in perfect parallelism while they undergo wear. The exact cross-section of the feed-stream will vary somewhat with the hardness of the different materials to be crushed. This can be easily adjusted by varying the amount of bevel given to the edges of the angle-iron

and of the guide-plate in the feed-tray until the feed-stream exerts the desired uniform abrading action.

The flanges upon the longer roll-shell perform two functions. They not only confine the feed-stream at its ends, and prevent ridges from forming at the ends of the unflanged roll-shell, but by carrying the feed-stream a slight distance beyond the end of the shorter roll-shell, a small amount of crushing is performed between the sides of the flanges and the ends of the roll-shell. This flange-crushing, being in opposite directions, balances, and all tendency to exert end-thrust of the shafts against their bearings is thus neutralized and overcome. By the simple means thus provided it becomes possible for the roll-tender to maintain the roll-faces parallel while crushing even the hardest material, and to keep the rolls in continuous operation until the roll-shells are completely worn out. The only assistance required of a machinist is occasionally to turn off the edges of the flanges when they become so long that they strike the bolts of the opposite roll which hold its roll-core in place.

Figs. 7 and 8 illustrate the effect of Mr. Frazee's invention in connection with 12-in. and 24-in. roll-shells, in keeping their surfaces cylindrical until the shells are completely worn out. The 12-in. roll-shell shown in Fig. 7 has been reduced to 6.75 in. in diameter.

The 24-in. roll-shells shown in Fig. 8 have been reduced to 19.25 in. in diameter, leaving a thickness of only $\frac{3}{8}$ in. of metal at their edges. At their centers they are somewhat thicker, owing to their beveled inner surfaces, which are required in order to mount them upon their coned centers. A pair of the 24-in. crucible-steel roll-shells, 14.5-in. face, when machined and ready for use, weigh approximately 1,776 lb. When worn down to the size shown in Fig. 8, their weight is 438 lb. The difference—viz., 1,338 lb., or 75.3 per cent. of the original weight—has been entirely expended in useful and effective work. Such a novel and valuable result, whereby the efficiency of the crushing-rolls is maintained uniform while the roll-surfaces undergo wear, clearly marks a step in advance in the art of roll-crushing. The only machine-work required, as already explained, consists in a partial removal of the flanges on the longer roll-shell as the wear of the shells per-

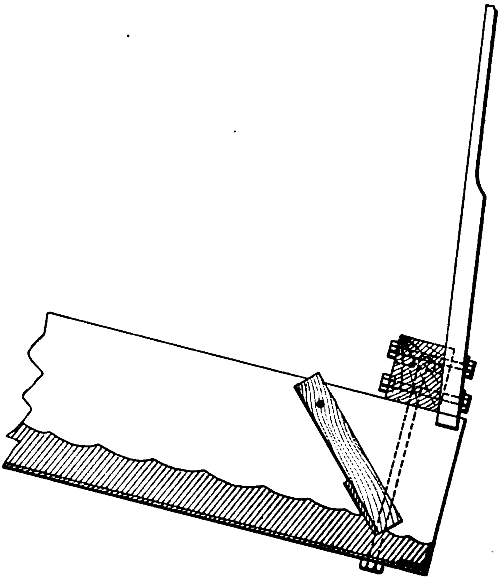


FIG. 5.—LONGITUDINAL SECTION OF END OF FEED-TRAY.

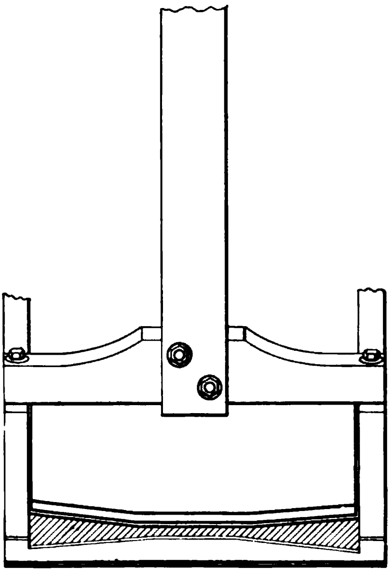


FIG. 6.—END-VIEW OF FEED-TRAY.

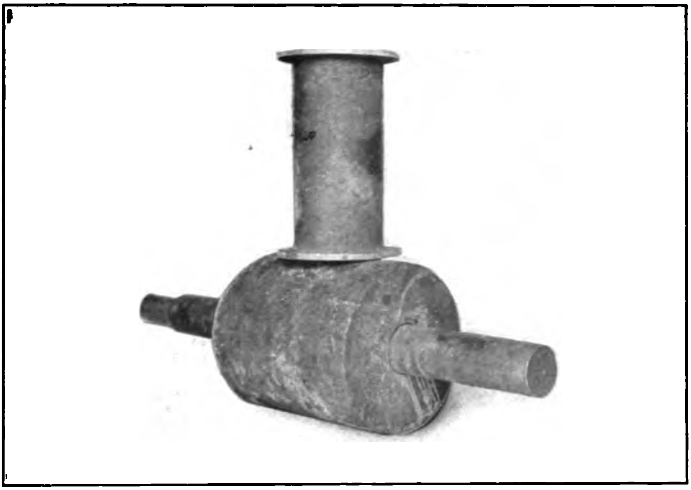


FIG. 7.—A 12- BY 14-IN. ROLL-SHELL, MOUNTED UPON ITS SHAFT, AND A FLANGED ROLL-SHELL OF THE SAME ORIGINAL SIZE WORN DOWN TO 6.75 IN. IN DIAMETER, ITS SURFACE BEING MAINTAINED CYLINDRICAL WITHOUT ANY MACHINE-WORK HAVING BEEN EXPENDED UPON IT.

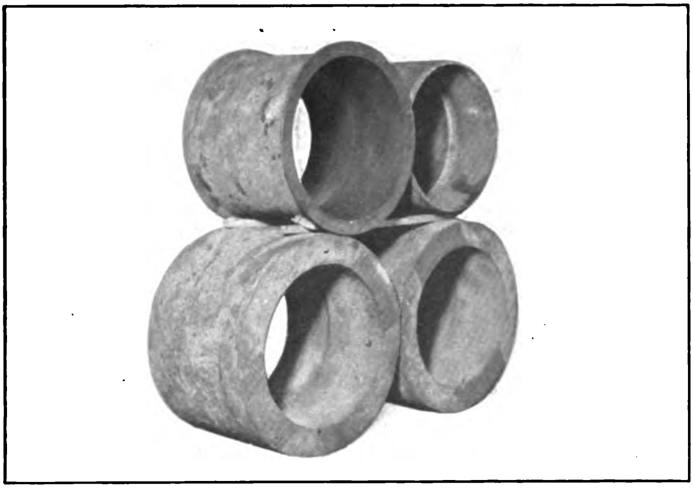


FIG. 8.—A PAIR OF WORN-OUT ROLL-SHELLS ORIGINALLY 24 IN. IN DIAMETER AND REDUCED TO 19.25 IN. IN DIAMETER BY WEAR ALONE, PLACED ABOVE A PAIR OF 24-IN. STEEL ROLL-SHELL CASTINGS.

mits the flanges to approach the draw-bolts of the coned centers.

While the method of feeding the rolls which Mr. Frazee has adopted accomplishes admirably the purpose for which it was designed, and secures a close control over the feed-stream at its point of discharge, it is evident that the same principle might also be adapted to other types of feeders, such as the roller-feeder, the shaking-feeder, the plunger-feeder, the scraping-feeder, etc.

This new roll-design and manner of operating rolls has been developed by Mr. Frazee in connection with the dry crushing of very hard materials used for abrasives, such as quartz, garnet, etc. It is equally applicable to ores, and by the settling and removal of water from the mill-feed, it is possible to apply it to wet crushing as well as dry. The field which is thus opened up in connection with ores which require careful granulation, in order to prepare them for concentration, is a very large one.

Perhaps the most interesting and obvious application of Mr. Frazee's new roll-design is in connection with the treatment of complex ores. Innumerable processes have been proposed for the recovery of the values contained in these perplexing ore-mixtures, but they may be divided broadly into two classes, viz., that which includes mechanical methods, and that which includes all the others, such as chemical processes, leaching, smelting, etc. While the former are the least expensive, the results heretofore obtained have been proximate only, and the recoveries have shown a low efficiency. All of these mechanical processes, whether they employ gravity, magnetic, electrostatic, or flotation methods (with the single exception of the flotation process adopted by the Minerals Separation Co., Ltd.), require an ore to be crushed to a point where the separate minerals it contains are sufficiently unlocked to permit them to be mechanically separated from each other, so that they may be collected in different groups. The point does not seem to have received sufficient attention, that any one of the above mechanical processes of treating complex ores can be seriously interfered with, if not completely upset, by the means employed to crush such ores in preparing them for treatment.

The mineral association of these mixed sulphide ores is usually a very intimate one, so much so that in many cases it

involves crushing them to pass a 30- to 40-mesh screen, or even finer, in order to sufficiently unlock the associated minerals.

By the ordinary methods of crushing there is great danger of producing a large amount of fine powder, or slime, in crushing to such sizes. Particles of a very minute size, usually placed at about 200-mesh, then become, in a measure, a law unto themselves, and the losses in treating such material are very great. The obvious way to solve the dust, or slime, problem is not to make any dust, or slime, or as little as possible, in crushing these ores for mechanical separation.

The future of the mechanical processes of ore-treatment, in competition with others which promise larger returns, will thus depend, in many cases, upon successful granulation. In this direction I believe that Mr. Frazee's invention, as outlined above, has accomplished a great step in advance in the art of roll-crushing, and it holds out great hopes for the future in the more successful preparation of many ores for mechanical concentration, by reason of the control he has secured over the wear of his roll-shells, whereby a better granulating action can be obtained.

Discussion.

E. G. Spilsbury, New York, N. Y.:—Do I understand correctly that the rolls are at first simple cylinders, one longer than the other, and that flanges are subsequently formed on the longer roll as the result of wear only?

Mr. Payne:—The flanges are formed by the wearing of the shorter roll into the other, which is about an inch longer. When the roll-shells are new, the longer one has machined at each end a ridge about ¼ in. or 0.25 in. higher than the face. These slight projections help to center and steady the rolls, by locating the flanges in advance.

Possibly they might be left off at the start; but Mr. Frazee has found it better, in machining the new roll-shells, to turn such small flanges upon the longer one. In his practice the feed-stream is extended a short distance beyond the two ends of the shorter roll-shell. This allows a small amount of crushing to be done between the flange-faces and the vertical ends of the shorter roll-shell, which prevents any ridges from forming at the ends of the shorter roll-shell.

In common practice, where two roll-shells of the same width are used, it is impossible to prevent ridging of the diagonally-opposite ends of the roll-shells. These ridges prevent accurate work in fine crushing. They also exert end-thrust upon the shaft, and strains upon the roll-frame. In Mr. Frazee's design the flanges not only act as movable check-plates, but they overcome all end-thrust upon the roll-shafts, and by preventing ridges from forming at the ends of the shorter roll-shell, they help to maintain the roll-faces in perfect parallelism while they undergo wear. The flanges become, therefore, of great importance in fine crushing. When they extend so far as to strike the draw-bolts of the shorter roll-centers, they are cut off.

Prof. Robert H. Richards:—One of the great difficulties in ordinary rolls is to get an even feed. How is the feed brought to this roll (indicating)? If the feed came more in one place than in another, that place would wear more.

Mr. Payne:—That raises a very interesting question. Mr. Frazee has found that an even, or uniform, feed is not desirable. In fact, a uniform feed produces irregular wear. This is certainly true in the case of fine crushing, in spite of the general opinion of roll-manufacturers to the contrary.

The reaction of a feed-stream upon the crushing surfaces of roll-shells is a subject to which little attention seems to have been directed heretofore. Mr. Frazee has found that in order to maintain the roll-faces parallel, it is essential to feed a larger amount of material along the sides of the faces than at the centers of the roll-shells, as explained in my paper. This seems to be partly due to the unequal mobility of different portions of the feed-stream as it is subjected to the crushing-pressure.

Differences of mobility would naturally cause differences of abrasion. A certain analogy may, perhaps, be found in the different rate of flow of metal in different portions of a hot ingot while passing between reducing-rolls. Whatever the reason may be, it has been found by actual practice that irregular abrasion of the roll-shells can be prevented by varying the thickness of the feed-stream in such a way that a larger amount of material is fed towards the ends than at the center of the roll-shells.

A further advantage of Mr. Frazee's roll-design, resulting from the high crushing-efficiency attained by control over the wear of the roll-shells and balanced end-thrust, is, that the roll frame can be made considerably lighter than would otherwise be possible. By reason of the reduced strains, single side-frame castings, bolted together, can be used to support the roll-bearings in place of the usual massive continuous bed-plate casting. In actual operation these new rolls run almost as smoothly as a lathe. The 24-in. rolls are run at 100 rev. per min.; the 18-in. at 150, and the 12-in. at 250.

This system of crushing has been developed gradually. There are eight of these rolls now in actual operation, all exhibiting the same uniform control over the wear of the roll-shells. It is therefore not a "happy hit," but the result of close study of actual conditions on the part of the millman rather than of novel design on the part of the mechanical engineer. For this reason I think the new roll-design of Mr. Frazee's is of especial value and interest.

Professor Richards:—There is a comic side to this: When we were preparing the first two volumes of our book on "Ore-Dressing" we had all our data in; and then the Wilfley table was developed, and that knocked the underpinning from under our plans. Now, we have our third and fourth volumes out, and we have taken great pains to show that flanges should be prevented, and now it turns out that the flanges are the best things to have. It reminds one of the old darkey's phrase, "The world sure do move."

George C. Stone, New York, N. Y. (communication to the Secretary *):—It seems to me that the principal novelty in the Frazee rolls is the feeder. Flanging one roll was common in Joplin a few years ago; while this helped to keep the roll-faces true, it was generally abandoned because the flanges, being made of cast-iron, frequently broke and caused much trouble when the pieces got into the jigs. Connecting the two adjusting-screws by a chain and sprockets is practically what has been done with other rolls. The feeder, however, is a new arrangement, and I believe a very good one. Even without the testi-

* Received Feb. 16, 1912.

mony of Mr. Payne's photographs, I should expect, from my own experience, that it would tend greatly to keep the faces true.

A few years ago we had a mill consisting of a 10 by 20 crusher, two 6 by 20 breakers in parallel, and a pair of 20 by 28 Krom rolls. When in good condition this just about kept the works in operation. We found, as Mr. Payne says, that the tendency of the rolls to wear hollow in the middle greatly reduced the capacity of the mill and necessitated much loss of time in shutting down to turn off the rolls. We first tried a pair of hard-steel rolls, but found that they greatly reduced the capacity of the mill, as the hard surfaces would not bite, but slipped, and the rolls packed full and threw off the belts, making it necessary to shut down and shovel out. Our next trial was with a feeder on the principle of Mr. Frazee's. While not as efficient as his, it decreased the trouble from uneven wear enough to answer our purpose. This device was a series of V-shaped riffles in the feed-chute. They were half round, about 0.5 in. in diameter, and placed with the points upward, so as to throw more feed to the sides than the center of the rolls. By a little experimenting we found what spacing and angle of these riffles gave us approximately even wear of the rolls. This very simple arrangement greatly increased the time the rolls could be run without requiring to be turned off, and enabled the work to be done without increasing the size of the mill.

S. Arthur Krom, Plainfield, N. J. (communication to the Secretary) * :—Mr. Payne's statement that S. R. Krom was the "pioneer" in introducing into the United States crushing-rolls driven by belts, is, to the best of my knowledge, correct; but Mr. Payne's statement that S. R. Krom introduced high-speed rolls is not correct. As we understand the term "high-speed" —namely, a peripheral tire-velocity far greater than the falling velocity of the feed—such machines have never been built by any Krom manufacturer. Krom rolls have always been driven only slightly in excess of the feed-velocity. A high-speed roll, introduced a few years ago, naturally failed. Such a roll, revolving ahead of its feed, requires additional power, and is

* Received Mar. 27, 1912.

subject to additional wear on its bearings, without accomplishing any more work.

The ball-and-socket bearing, which Mr. Payne mentions, has only been adopted by those makers who were unable to design and build a roll with a "back-bone" stiff enough to stand up and do its work like a real roll. Such a bearing is a poor substitute, involving, as it does, extra parts in a machine that, owing to the nature of its work, should have as few parts as possible.

I think the use, for reducing large sizes, of the giant rolls mentioned by Mr. Payne, is, both mechanically and economically, a mistake. Rolls used for such work encroach upon the field of machines far better adapted to it. The cost of the jaw- and gyratory crushers for installation, power, and repairs is, in proportion to the work done, so much smaller than that of giant rolls as to counterbalance any advantage claimed for the latter in other respects.

The following extracts from a letter, dated Mar. 1, 1911, by a user of the giant rolls, who has had experience with jaw-crushers and three different makes of gyratory crushers, explain themselves:

"Our rock comes in very hard pieces; and at the time we made the change in our plant, a 42-in. opening was the largest gyratory crusher being built; so we decided to put in rolls. . . . .

"We found that in order to keep the rolls in fairly-good shape, we had to put on two new tire-plates each Sunday, at a labor-cost of from $30 to $50. Two plates with freight cost about $185, making a total of about $225 per week.

"It is one man's work to look after the oiling of the four bearings. If, for any reason, they should run dry for a small fraction of a minute, the rolls would be out of business. . . . .

"We operated the rolls 4 months and averaged 400 tons per day; but this small output cannot be charged against the rolls, as we had but one shovel and a great deal of trouble with the electric power.

"We had a 200-h.p. motor for each roll, and it took from 5 to 8 men with a lever to help start them.

"Three hundred and twenty 2.5- by 10-in. bolts are used to fasten the plates to the rolls. Occasionally a bolt breaks, and in going through the mill with the tailings is sure to do damage to the machines used for secondary crushing. In this way we broke three shafts in our No. 6 crusher.

"The price of 7 ft. by 3 ft. 6 in. rolls is about $25,000, in addition to a royalty of two cents per yard.

"If I were to build a plant now I would use a Kennedy machine. I believe his crusher, with the improved eccentric, is the best thing on the market to-day."

A jaw-crusher constructed upon certain lines, having a jaw-opening 10 in. by 20 in., and weighing not over 15,000 lb., will take a steady stream of 10-in. run of mine and reduce it without sliming to 1-in. size. To make such a reduction with rolls having equal capacity would require a roll at least 8 ft. in diameter, weighing about 80,000 lb. (see Fig. 1). The cost of the crusher would be about $1,500, and that of the roll, apart from the extra expense for foundations and transportation, about $8,000.

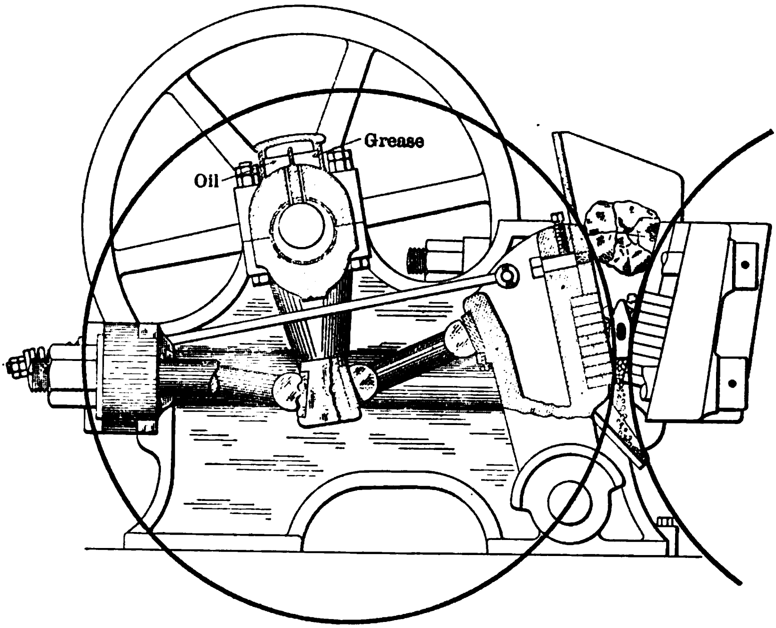


FIG. 1.—KROM CRUSHER.

Comparison of 10- by 20-in. Jaw-Crusher with Rolls for reducing from 10 to 1. The circular outlines represent Roll-Tires 8 ft. in diameter, which would be necessary to bite a 10-in. ore chunk.

The practice of dropping the feed from a considerable height to the roll, in order to drive it through by force of its falling-velocity, would permit the use of a somewhat smaller roll. But the height required is in most cases not available, hence additional expense for elevating would be involved. Moreover, the violence of this method of feeding and crushing would, in ore-milling, produce an excessive amount of slimes.

Again, it is desirable in such operations to remove the "fine

enough" material as fast as it is produced. The product of the giant rolls, containing a large amount of coarse material of various sizes, would require a very extensive screen-system to remove the fines, the ore passing through a number of graded coarse screens, until an oversize was obtained that would not destroy the screen removing the finished product. It is better practice to crush uniform at each step of the reduction, and screen near the end of the operation, thus making the screen-installation as simple as possible.

In ore-milling, the use of rolls is desirable when it is necessary to keep the slimes down to the smallest possible amount. Their ability to do this is their most valuable feature, but this point has often been overlooked, and rolls have been used for purposes unsuited to their construction.

It has been found in general ore-milling practice that a reduction of 4 to 1 should be the limit for rolls, under the most favorable conditions. A reduction of 3 to 1 is the average, and often it should not exceed 2 to 1; so that in actual practice it would require a 30-in. roll working in connection with the 8-ft. roll to produce the 1-in. crusher-delivery size; the first roll reducing from 10 to 3, and the latter from 3 to 1.

A good roll, like a good horse, will stand (and generally receives) an awful lot of abuse; but experience shows that it does not pay to abuse a roll, any more than a horse. I once had a customer who insisted on reducing quartz from 2-in. to fine powder, with one set of 30-in. rolls. I could see that this man was anxious to be a "pioneer." Somehow or other he did not break the roll, but he did break his company.

Rolls for Fine-Crushing.—Mr. Payne says that "rolls for fine crushing, namely, to pass 30- to 40-mesh, etc., have not given satisfaction, and since little assurance can be given that they will do so and retain the granular feature of the crushed product, they have been assailed by various types of tube-mills, etc." My experience with rolls has taught me that the product of a roll is always granular, no matter how fine the crushing is. The attack on rolls for fine-crushing by tube-mills, etc., is to my mind justifiable, since, below 20-mesh, the capacity of the roll becomes too small for general mill-practice, in proportion to its installation- and operating-cost; and the capacity diminishes very rapidly with the fineness of the crushing.

Mr. Payne says that "the loss of capacity is due to the escape of the ore-particles through the rolls, owing to irregular or grooved tires." This is true to a certain extent; but the principal cause for the loss of capacity is the fact that the stream of mineral passing through the roll has, by reason of the fineness of its individual particles, become very thin, hence its tonnage drops off. Choke-feeding does not remedy this to any extent, and is difficult to regulate. The only remedy is a greatly increased surface for action, *i. e.*, more mineral surface to act on, and more crushing-surface to perform the work. Here the roll must give up the job to a machine fulfilling the above requirements.

Such a machine is found in the modern pebble-mill of the Hardinge type. The granular nature of the product from this machine is not lost to any damaging extent, and for fine-grinding operations the production of slimes can be kept within reasonable limits, considering the fineness of the work, by proper regulation of the feed and the adjustments of the mill. The mill is no more "fool-proof" than a roll is—which is no drawback in the ore-milling business. I have yet to see a milling-proposition that would pay a profit if operated by fools. I do not know where the term "fool-proof" machinery originated, but I think it must have been invented to fit some local condition in Joplin, Mo.

In regard to the grooving of tires, I have often found it due to uneven texture of the tire-metal. Under such a condition, grooving will take place, no matter how even the feed. A practical mill-man can easily arrange any one of several feeding-devices now on the market to deliver an even feed. In case of unavoidable tire-grooving, various methods of truing up the tires are successfully practiced. John Sargenson, of the Nipissing Reduction Works, Cobalt, has developed a simple apparatus for doing this while the roll is at work.

The Frazee method of dry-crushing, as outlined by Mr. Payne, could not be adapted to general mill-practice, since it would be impracticable or too expensive to dry the ore for crushing, and then wet it again for concentration, cyanidation, etc.

There is nothing new about the principal features of the Frazee roll-construction, such as the spring arrangement, ad-

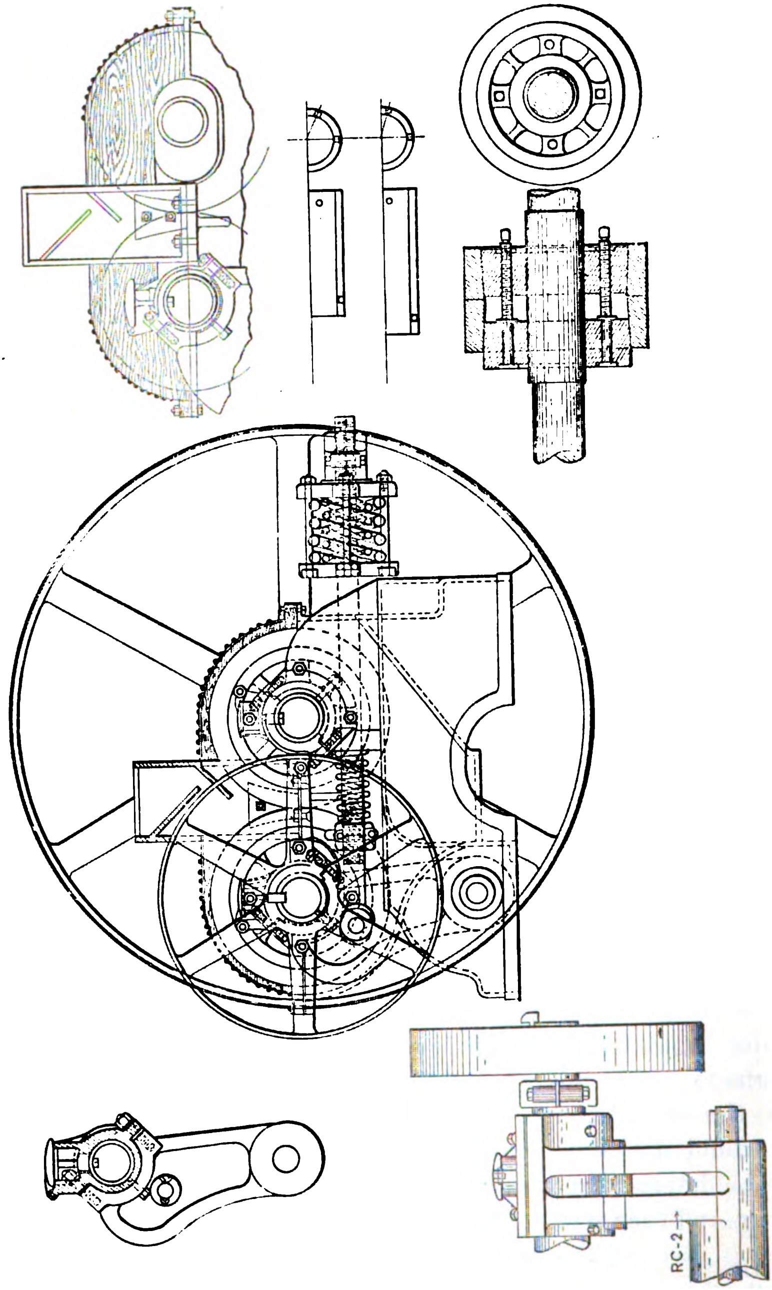


Fig. 2.—Krom Roll.

Detailed drawing showing correct roll-construction. The movable bearings are connected by a solid yoke, RC-2. This yoke holds the movable bearings in perfect alignment and parallel to the fixed bearings.

justment, flanged tires, etc. They have all been used from time to time, and are now chiefly epidemic in the Joplin region, and are responsible, together with other local conditions, in making that district notorious for poor milling-practice.

The following illustration will further enforce and explain the foregoing remarks:

Fig. 2 shows detail-drawing of correct roll-construction. The movable bearings are connected by a solid yoke, RC-2 (see lower left-hand corner of drawing). This yoke holds the movable bearings in perfect alignment and parallel to the fixed bearings.

In the Hardinge pebble-mill,[1] the multitudinous crushing-surfaces formed by the contact of the pebbles with the walls of the mill, and between the pebbles themselves, is a mechanical feature with which a roll cannot compete. It will be noted from the results given in the accompanying test-card that with a comparatively coarse feed, 4-mesh, only 35 h-p. is required to give a capacity of 65 tons per 24 hr., reducing to sizes fine enough to meet the requirements of the average tailings-regrind.

CARD NO. 33. DATE NOVEMBER 3, 1910.

Mesh-Test Card, Hardinge Conical Mill Co., New York.

Class of Ore:—Lake amygdaloid copper.
Mill used in test: 8 ft. in diameter, conical pebble mill.
The following shows mesh-sizes before and after reduction:

Through 4-Mesh.	Feed to Mill.	Product from Mill.
	Per Cent.	Per Cent.
On 8-mesh,	40.3	
On 10-mesh,	25.0	
On 20-mesh,	29.0	
On 40-mesh,	4.5	2.7
On 60-mesh,	0.5	8.5
On 80-mesh,	0.1	3.3
On 100-mesh,	....	9.4
On 150-mesh,	....	30.2
On 200-mesh,	....	10.9
Through 200-mesh,	....	34.0

REMARKS:—Capacity, 65 tons per 24 hr.; charge pebbles, 8,000 lb.; speed, rev. per min. of mill, 28; horse-power, 35; water, gal. per min., 15.

The effectiveness of the increase in crushing-surfaces is further demonstrated by the small percentage remaining on 40-mesh.

[1] *Trans.*, xxxix., 336 (1909).

In cases where it would be necessary to crush the original ore to 40-mesh or finer, before beginning concentration, it would also be better practice to carry the roll-crushing to about 6-mesh only, classify out the "fine enough," and finish the oversize with the pebble-mill. Slime-tables have now reached such a degree of perfection, both as to low cost of operation and high recovery of the values, that it would be much cheaper to install extra tables to take care of the slimes produced by the pebble-mill, crushing 6-mesh feed, than it would be to try to avoid making slimes, and at the same time crush very fine with non-sliming machines of a small capacity, making fine reductions.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

A Concise Method of Showing Ore-Reserves.

BY N. H. EMMONS,* KNOXVILLE, TENN.

(New York Meeting, February, 1912.)

THE work of a consulting engineer or manager, when controlling mining-operations, requires that he have all the information concerning the mine in as concise a form as possible, and as the ore-reserves and their depletion and enlargement are the vital points to be studied, it is well to have them kept up to date and in some convenient form.

The present paper describes a method adopted by me, which shows in a very clear manner the ore-reserves in a mine. The case illustrated is that of a vein near enough to the vertical for the vertical elevation of the mine to be the main working-map. A flat ore-body would be represented on a similar plat, but instead of the horizontal thickness of the vein being shown in the circles, the vertical thickness would be inserted.

Fig. 1 represents an ideal longitudinal elevation of a mine, plotted in the ordinary way, using 100-ft. blocks and section-lines. In a mine where the block-numbers are posted by the engineer underground, the system of keeping the ore-tonnages extracted from the different blocks is easily maintained, and the actual tonnages of ore extracted can be kept so that the surveyor can have a check on his estimate from time to time.

The ore-reserve sheet, Fig. 2, should be the same size as the map it is to accompany. Each square is used for the description of the ore-reserve in the block it corresponds to on the elevation. Where the section-lines cross the levels a circle is drawn, in which are written the widths of ore at that point, these widths being used in the calculations of each block cornering in the circle. It has been found convenient to show the figures in black in the lower half of the circle when the actual widths of ore are known, and when it is necessary to make up the figures of probable ore, as at the time of making

* Consulting Engineer.

annual or semi-annual reports, red figures are written in the upper half of the circle to represent the probable thickness of the ore; and later on, when the development warrants it, the black figures are inserted underneath. The same color-scheme may be used for ore actually developed and probable ore, red

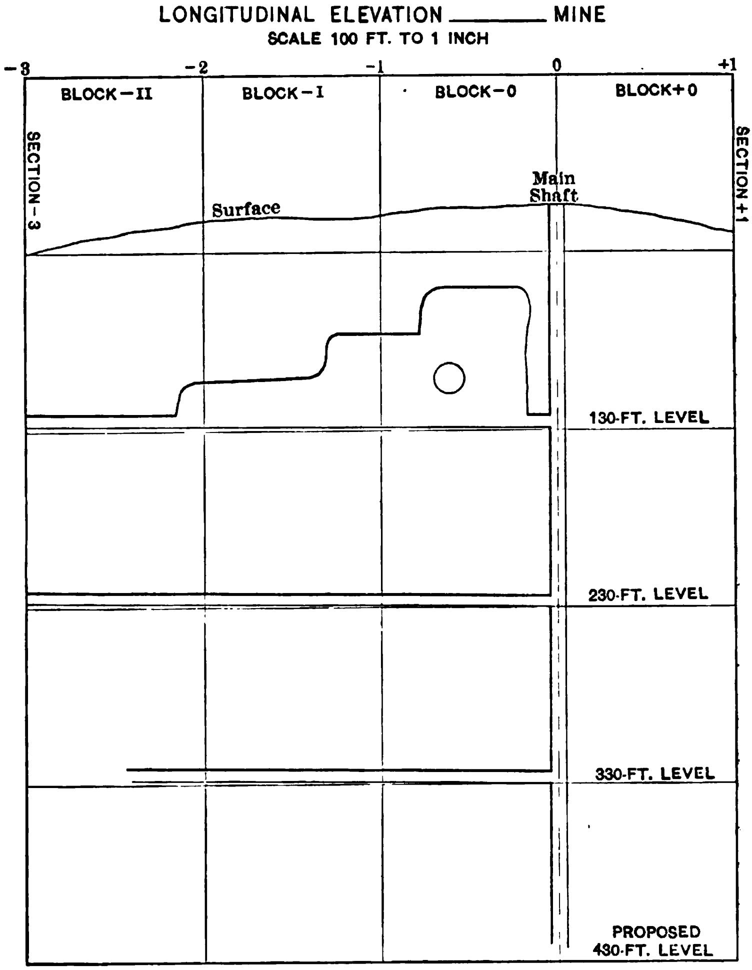


FIG. 1.—IDEAL LONGITUDINAL ELEVATION OF A MINE.

figures representing the probable ore being first inserted in the column headed "Developed," and when the ore is developed the black figures should be inserted in the time-space when the development was completed.

There should be an ore-reserve sheet for each year, and the space between the levels divided into four spaces if quarterly estimates are made, as shown on the 130-ft. level, or into 12 spaces if the figures are worked up monthly, as shown on the 230-ft. level. Then there should be a sheet kept to enter the ore developed and extracted each year, 10 spaces being a con-

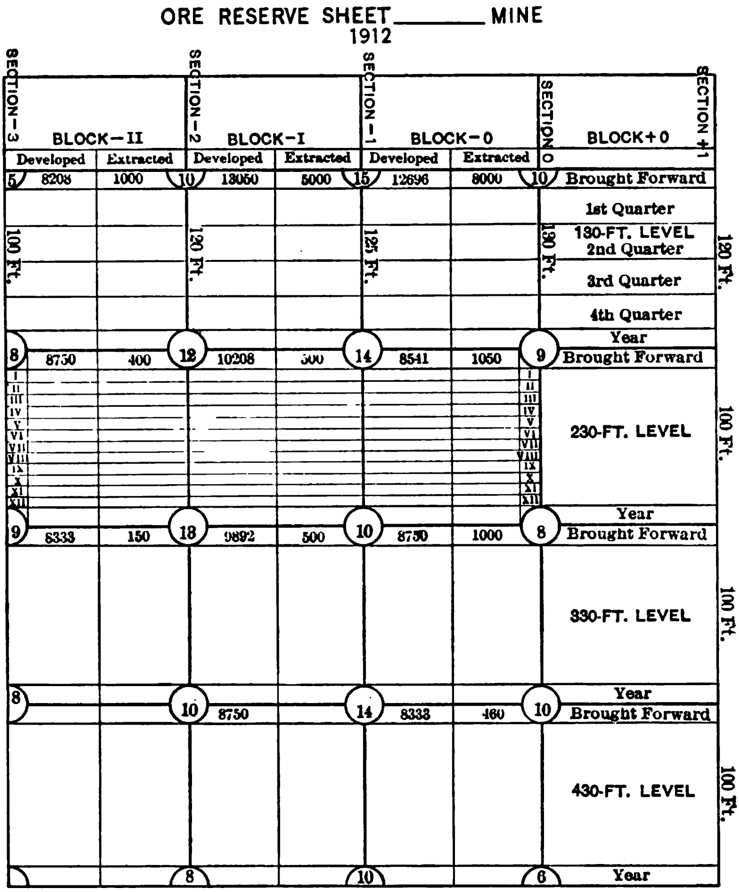


FIG. 2.—ORE-RESERVE SHEET TO ACCOMPANY ELEVATION, FIG. 1.

venient number, thereby covering 10 years, so that the record of the development and extraction by years can be seen at a glance.

In mines where the value of the ore is kept it is convenient to insert in one lower quarter of the circles the width of the

ore, and in the second lower quarter the value of the ore. The idea can be carried a little further by using squares instead of circles at the corners, in which the widths and values are written, and making a circle in the center of each large block in which to insert the average value of the block of ore.

As it is always well to have the figuring in some permanent form so that it can be readily checked, a sheet, Fig. 3, should be kept for each level, showing clearly how the tonnages were calculated.

ORE-RESERVE CALCULATION-SHEET ——MINE

First Level. January 1, 1912.

Block No.	Section No.	Average Width of Ore at Section.	Depth of Ore.	End Area or Area at Section.	Average End Areas.	Length of Block.	Volume Cubic Feet in Each Block.	Developed Ore, Tons. 12 Cu. Ft. = 1 Ton.	Probable Ore, Tons. 12 Cu. Ft. = 1 Ton.	Remarks.
	0	$\frac{10+9}{2}$	130′	1,235						All Ore Developed Previous to Jan. 1, 1912.
—0					$\frac{3,047}{2}$	100	152,350	12,696		
	—1	$\frac{15+14}{2}$	125′	1,812						
—I					$\frac{3,132}{2}$	100	156,600	13,050		
	—2	$\frac{10+12}{2}$	120	1,320						
—II					$\frac{1,970}{2}$	100	98,500	8,208		
	—3	$\frac{5+8}{2}$	100	650						

FIG. 3.—ORE-RESERVE SHEET.

If the ore-reserve sheet is posted monthly, a great deal of information can be gleaned, a splendid record of operations is obtained, and the work for the future is planned to the best advantage. Another important point is that the percentage of ore recovered, when a stope or block is worked out, can be readily seen, and estimates of the available ore in other blocks can be made with greater accuracy.

Each problem may require a different form of reserve-sheet, and the sheet can be varied to suit any mine-map.

One of the main advantages of the sheet is that it will teach the mining engineer to make careful estimates of ore-reserves, and not, as in many cases is done now, allow the mine-foreman to say that there are so many tons in such and such a stope that will require so many months to take out.

The development of the mine is so clearly shown, if the sheet is kept properly posted, that the management can tell at any time whether the development is running behind the extraction, or just what is going on. There is no reason why a mine should not have its ore-reserve book balanced every month in as careful a manner as are the accounts, if such a system as the above is kept, and at the end of the year it will save many disappointments at the small amount of new ore developed if the question has been kept continually before those in charge.

Another point that is so often handled in a dilatory way at mines is the method used for figuring an estimate, and the keeping of this information regarding widths of ores, values of ore, and estimates of ore-bodies on various slips of paper or in numerous note-books. If the reserve-sheet is being kept, there will be definite methods and exact figures needed at least once a month or a quarter, and as these figures are obtained if there is a place to put them, they will be entered on the final sheet as soon as obtained.

Take, for instance, a drift in ore of varying width and assay. If the method of estimating ore in use at the mine is to sample and assay every 10 ft., then the average width and assay of the 50 ft. on each side of the circle or corner is made up and inserted in the circle, the amount of ore in the four blocks contiguous to the circle worked out, and posted in the month when the actual figures are made up.

If ore-reserves are classified, then a separate sheet should be used for each class of ore. Many mines produce smelting-ore and concentrating- or milling-ore from the same block. A smelting-ore sheet should be kept and the width of this class of ore alone be entered on one sheet, and that of the concentrating-ore on another.

Another far-reaching point in favor of such a record is that it can be seen at a glance if the high-grade stopes are being pushed too rapidly and the low-grade being neglected.

It is the custom of many companies to have maps of the

mines sent in with annual reports, with the intention of keeping the directors posted regarding the development of their property. How much better would it be to send in an ore-reserve sheet as outlined above, that would convey the exact information about what was actually being done at the property, and be easily understood.

Discussion.

E. W. King: The form of measuring up ore in sight looks very plausible, as illustrated in the paper of Mr. Emmons, but from my experience of many years of mining in Montana and Nevada, I have found it is very hard to measure up anything nearer than a guess of what you have in sight, except in the case of a true vein, or a flat vein where the boundaries are well defined. I have been interested in several mines with Dr. A. R. Ledoux, and I know that my foreman and myself, going into the mines and using our best judgment, could seldom see more than 30 days' supply actually in sight, and yet we were running from 100 to 250 tons a day, and keeping it up year after year.

Prof. John D. Irving: I understand from Mr. Emmons that this is a method which has been found applicable in the copper-mines in Tennessee, where the record could be made with a good deal of accuracy, and where the work in the mines allowed the necessary development to be done, so that the record could be kept up. I do not think there was any intention in his mind to imply that this was applicable to all cases, especially such as Mr. King has mentioned.

President Charles Kirchhoff: I think the point is that the paper impresses the necessity for doing it where the possibilities exist. There has been too little attention given to this very matter, particularly in the United States; but I think our English friends are following it very much more zealously, and the demand for it there is possibly greater than it is here, because English boards of directors handle mines that are often very much further away than our own are, and the English public and the English engineers generally are very much more insistent upon seeing how much longer current dividends are going to last, or current assessments are going to continue.

WILLIAM KELLY: My only criticism of Mr. Emmons's paper is that the adaptability of the method to various conditions is not quite as clearly stated as it might be. In the Lake Superior region, with which I am most familiar, a system such as this could probably not be used. In ore-bodies running from zero to 200 or 300 ft. in width, a vertical longitudinal section would not represent the whole width. The difficulty usually to be met is not so much in estimating the quality of the ore in the developed part of the mine as in estimating the ore in that part of the mine which is only partly developed, or in that part which is at present beyond development, and yet to which we have to give some value.

DR. N. S. KEITH: This manner of exploring a mine becomes most important in the low-grade ores, such as are found, for instance, in Arizona. At the Ray Consolidated mine they have, according to latest reports, about 30 miles of underground work, done simply for exploration, the reason being that such a large amount of capital is necessarily expended in the erection of mills and works, there must be a reasonable certainty of profit for a number of years, in order to return the capital invested. The little Ray Central mine, which is about to be absorbed by the Leviathan, next to it, has about 6 miles of underground work, extending in depth to about 400 ft., and including levels, drifts, and winzes, etc., which have exposed bodies of workable ore of various sizes. These have been cut up into blocks about 200 ft. square at the various levels, and winzes have been run to determine the amount of ore available. The Ray Consolidated, though it has but just begun its concentration-works, has in this way developed more than 77,000,000 tons of ore. The Ray Central has developed something like 12,000,000 tons. One body, for instance, was found which the engineer estimates to contain 700,000 tons of ore, carrying more than 6 per cent. of copper.

There seems to be no other way to determine whether the necessary money should be spent upon the erection of works than to make these extensive developments beforehand. The Goldfield Consolidated people say they have developed two years' supply of ore, at nearly 1,000 tons per day. They do not think it was necessary to keep up greater development,

the geologist having reported that the ore will probably last for several years at least. At the Tonopah mine they keep ahead actually developed ore amounting to about two years' supply. They have pursued the same plan for several years, not doing any more exploratory work than seemed to be necessary, but keeping about two years of actual ore in sight.

At the Ray Consolidated, the maps are not kept on the plan proposed by Mr. Emmons, because their masses of ore are very thick blankets, and are divided into blocks of 200 ft. square, to represent the average values, by assaying the surface exposed, and doing so at every 5 ft. The Ray Central keeps all the necessary records at the mine, and has models of the mine on glass plates at the New York office. Their system of marking is somewhat different from that given by Mr. Emmons, and is very interesting and easily understood. The assembled glass plates represent the several levels; and the horizontal sections of the several ore-bodies at these levels are designated in colors. These, with the shafts, winzes, and levels, are easily seen in their relative positions.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Refining of Blister-Copper.

BY HORACE H. EMRICH, KYSHTIM, RUSSIA.

(New York Meeting, February, 1912.)

PREFATORY NOTE.—The first part of this paper was sent to me by Mr. Emrich nearly nine months ago; and I held it, waiting for the second part, which he had promised to forward soon, so that I might submit the whole to some of his former professional associates, and advise him of their criticisms and suggestions before offering his work to the Institute. But, five days before the second part reached me, I received by telegraph the news of Mr. Emrich's sudden death. The paper has therefore not had the benefit of such a revision by the author as might have made it in some respects clearer and more complete. Nevertheless, I believe that experts in the branch of metallurgy with which it deals will find it both original and suggestive.—A. EILERS.

I. PARTIAL REFINING IN THE ANODE-FURNACE.

During my connection with one of the large New Jersey copper-refineries, and probably before that period, from 15 to 20 per cent. of the copper-bullion received was the very foul, leady blister-copper produced from lead blast-furnace matte. It had been customary to mix a small part of this blister with each charge of purer pig-copper, in the effort to dilute it as much as possible before casting into anodes; but tank-house conditions were such that I was led to try making entire furnace-charges of this blister, and refining it as much as possible in the furnace—afterwards casting to anodes and refining electrolytically, in tanks and solution separate from the main bulk of the purer copper.

In making this experiment, notes were made, for several furnace-charges, of everything thought to have a bearing on the question, and some interesting facts were brought out, both in the furnace-working and afterwards in the tanks.

The changes taking place during the furnace-refining are shown by the results of working two typical charges. The refining was done in a magnesia-lined, reverberatory refining-furnace of the usual design, built to cast 150 tons per charge.

Each lot of copper charged was taken at the settlement-weight, as were also the assays and analyses; each slag pulled off was weighed, broken to fist-size to remove all copper shot, coned and quartered; and a barrelful (a clean oak barrel was used) was sent to the mill for final grinding and cutting down to the sample. All copper shot and metallics regained were weighed and added to the total of copper regained, since only the analysis of the slag itself was wanted. The sample, representing the copper as finally cast into anodes, was a composite of two plates cast from the pouring-ladle at different times during the tapping of the furnace. All copper not accounted for was reckoned as remaining in the furnace, with the same analysis as the anodes.

The various steps taken during the working of the copper and the results are as follows:

Charge A.

Tapped June 14, 1909. Copper Charged into Furnace.

	Cu.		Pb.		As.		Sb.		Total
	Per Cent.	Lb.	Per Cent.	Lb.	Per Cent.	Lb.	Per Cent.	Lb.	Weight. Lb.
Lot No. 1......	93.8	22,872	0.40	98	0.35	85	1.0	244	24,384
Lot No. 2......	93.8	80,494	0.78	672	1.41	1,213	0.42	362	86,090
Lot No. 3......	93.87	74,616	0.37	294	1.67	1,329	0.35	278	79,489
Lot No. 5......	94.18	81,172	0.64	552	1.61	1,388	0.35	302	86,189
Lot No. 6......	94.14	82,822	0.96	844	1.16	1,020	0.31	273	87,978
Total weight....		341,976		2,460		5,035		1,459	364,130
Average assay..	93.91		0.676		1.38		0.40		

The method of procedure in refining was thoroughly to oxidize the copper and attempt to remove lead, arsenic, and antimony by a copper-oxide slag. The pig was oxidized during melting by blowing compressed air, at 15 lb. pressure, through a 0.75-in. iron pipe thrust below the molten copper. With the large amount of lead present, the oxidation took place rapidly.

Each slag, as skimmed, was weighed and sampled, with the following results:

	Cu.		Pb.		As.		Sb.		Total
	Per Cent.	Lb.	Per Cent.	Lb.	Per Cent.	Lb.	Per Cent.	Lb.	Weight Lb.
First slag.....	44.2	2,187	8.9	441	2.3	114	3.3	164	4,958
Second slag..	38.7	2,950	10.2	778	2.3	175	3.5	267	7,632
Third slag....	36.6	1,600	9.8	428	2.3	101	3.3	145	4,374
Total slag........................									16,954

Average Assay of Slag Skimmed.

Au.	Ag.	Cu.		Pb.		As.		Sb.	
Oz. p. t.	Oz. p. t.	Per Cent.	Lb.	Per Cent.	Lb.	Per Cent.	Lb.	Per Cent.	Lb.
0.107	34.2	39.7	6,737	9.7	1,647	2.3	390	3.4	576

Removed from the furnace in slag: 1.97 per cent. of the Cu; 67.1 per cent. of the Pb; 7.7 per cent. of the As; 39.6 per cent. of the Sb.

It will be noticed that the amount of Sb driven off is very large; undoubtedly there is an error in the determination of Sb in the slag. It is probable that the results are double what they should be. (See analysis of slag drawn from charge B.) But this annoying error as to Sb does not affect the main argument, which is concerned chiefly with As. From the above figures it is seen that if the rate of the slagging of copper be taken as unity, the lead, arsenic, and antimony went into the slag at the following faster rates:

	Lead.	Arsenic.	Antimony.
First slag, . .	28.0	3.5	17.5?
Second slag, . .	36.6	4.0	21.2?
Third slag, . .	37.3	4.3	21.3?

Obviously, more slagging could have been done to advantage.

After cleaning off all slag, the copper was covered with coke and poled. It proved impossible to overpole this copper, though, in an endeavor to do so, on one charge (run later) 40 poles were burned, while the surface of the metal was kept well covered. Undoubtedly this was due to the action of the remaining lead as an oxygen-carrier.

Throughout the run, the surface of the copper gave off much smoke; and in casting so much was given off that the tapper complained of its making him feel somewhat sick. Even with a clear fire and when casting, a large amount of white smoke went off through the stack; of course, there was a great deal more during refining-operations. The figures given below show this to have been undoubtedly lead and arsenic, probably as oxides.

The total tapped from the furnace, including ladle-drip, slag, metallics, etc., was:

Au. Oz. p. t.	Ag. Oz. p. t.	Cu. Per Cent.	Cu. Lb.	Pb. Per Cent.	Pb. Lb.	As. Per Cent.	As. Lb.	Sb. Per Cent.	Sb. Lb.	Total Weight. Lb.
263	304.5	96.36	331,045	0.15	515	1.15	3,951	0.33	1,134	344,551
Copper unaccounted for, . . .					......	......	....	......	....	4,194
Equivalent to anode-copper left in furnace at 96.36 fineness, . .					......	......	....	......	....	4,352
Containing, ...					16	......	50	......	15	
Total impurities accounted for, .					2,168	......	4,391	......	1,724	

From these figures it is seen that the antimony-analysis is incorrect somewhere (probably being reported in the slag as twice what it should be), since they show more antimony accounted for than was in the original pig.

During all the poling-operations, some copper is driven off through the stack; and, as there is no ready means of determining how much this is for any charge, all difference has been assumed to have been left in the furnace, and, on the basis of the assay of the anode, the impurities in this residual copper are calculated as accounted for. On this assumption, the difference between the total impurities accounted for and the amount charged, must have been driven off in the fume while melting and refining, as follows: Pb, 11.85 per cent.; As, 12.70 per cent.; Sb, (?), of the total in the pig charged.

There was removed, therefore, in all the furnace-refining operations, 1.97 per cent. of the copper, 78.9 per cent. of the lead, 20.6 per cent. of the arsenic, and ? per cent. of the antimony in the pig originally charged; and, of the total impurities removed, 15 per cent. of the Pb, 62.2 per cent. of the As, and ? per cent. of the Sb, went off in the fume.

For the purpose of comparison the results of a second similar charge are given below. It will be seen that practically the same things occur.

Charge B.

Copper Charged into the Furnace.

	Cu. Per Cent.	Cu. Lb.	Pb. Per Cent.	Pb. Lb.	As. Per Cent.	As. Lb.	Sb. Per Cent.	Sb. Lb.	Total Weight. Lb.
Lot No. 12....	93.54	45,746	0.61	298	1.06	518	0.41	200	48,905
Lot No. 13....	93.13	41,316	1.51	670	1.26	559	0.36	160	44,364
Lot No. 14....	93.31	72,887	1.49	1,163	1.58	1,235	0.38	297	78,113
Lot No. 15....	92.95	23,075	0.63	156	2.14	532	0.64	159	24,825
Lot No. 17....	93.34	76,488	0.99	811	1.13	926	0.42	344	81,946
Lot No. 18....	92.58	60,599	1.68	1,100	1.32	864	0.43	281	65,456
Lot No. 19....	92.05	19,010	2.04	421	1.66	343	0.46	95	20,652
Total weight....		339,121		4,619		4,977		1,526	364,261
Average assay..	93.1		1.27		1.37		0.42		

This charge appears to carry the same amount of arsenic per ton as charge A.

The slag skimmed was as follows:

Au. Oz. p. t.	Ag. Oz. p. t.	Cu. Per Cent.	Cu. Lb.	Pb. Per Cent.	Pb. Lb.	As. Per Cent.	As. Lb.	Sb. Per Cent.	Sb. Lb.	Total Weight. Lb.
				First Slag.						
0.06	25.8	34.7	1,711	15.8	779	2.8	138	2.3	113	4,930
				Second Slag.						
0.14	38.0	34.3	2,127	16.5	1,024	2.6	161	2.0	124	6,202
				Third Slag.						
0.18	36.8	34.8	1,141	16.1	528	2.3	75	2.0	65	3,279
				Fourth Slag.						
0.07	17.5	15.4	297	20.1	388	0.3	6	0.1	2	1,930
				Total slag skimmed,						16,341

On the fourth skimming 200 lb. of lime was used to thicken the slag. It is apparent that, while the percentage of copper drawn off in this slag is not quite halved, the amount of lead is a quarter more, with gold and silver less; and it seems likely that more oxidizing and slagging would be of advantage in removing lead. The amount of arsenic and antimony in this slag appears to be very small, when compared with the previous slags, and is not what was expected, since, with the basic slag of lead and lime, more elimination was looked for.

Average Assay of Slag Skimmed.

Au. Oz. p. t.	Ag. Oz. p. t.	Cu. Per Cent.	Cu. Lb.	Pb. Per Cent.	Pb. Lb.	As. Per Cent.	As. Lb.	Sb. Per Cent.	Sb. Lb.
0.11	29.2	32.3	5,276	16.6	2,719	2.3	380	1.9	304

There was removed from the furnace in slag, 1.5 per cent. of the copper, 58.8 per cent. of the lead, 7.6 per cent. of the arsenic, and 19.8 per cent. of the antimony, in the pig charged.

Taking the rate of slagging of copper as unity, the impurities went into the slag at the following faster rates:

	Lead.	Arsenic.	Antimony.
First slag, . .	33.4	5.5	14.6
Second slag, . .	35.4	5.2	12.9
Third slag, . .	33.9	4.5	12.6
Fourth slag, . .	95.6	1.4	1.5

From these figures it is obvious that, in the last slag, arsenic and antimony were coming off at about the same rate as copper, and that no more could be hoped to be removed through

slagging. As to lead, however, it appears that conditions were very favorable in this slag for a high extraction.

										Lb.
Total tapped from the furnace, ...										333,765
Au. Oz. p. t.	Ag. Oz. p. t.	Cu. Per Cent.	Cu. Lb.	Pb. Per Cent.	Pb. Lb.	As. Per Cent.	As. Lb.	Sb. Per Cent.	Sb. Lb.	
1.81	333.4	96.0	320,414	0.26	868	1.15	3,838	6.32	1,068	
Copper unaccounted for and assumed to have been left in the furnace, .					......	......	......	......	....	13,431
Equivalent to anode-copper (at 96.0),					......	......	....	......	....	13,991
Containing at the above assay, . .					36	......	161	......	45	
Total impurities accounted for, . .					3,623	......	4,379	......	1,417	

The difference between this and the amount charged must have been driven off as fume while melting and working, as follows:

Pb. Lb.	Pb. Per Cent.	As. Lb.	As. Per Cent.	Sb. Lb.	Sb. Per Cent.
996	21.5	598	12.0	119	7.7

of the total in the pig charged.

There was therefore removed in furnace-refining 1.5 per cent. of the copper, 80.4 per cent. of the lead, 19.6 per cent. of the arsenic, and 27.5 per cent. of the antimony contained in the original pig charged, and, of the total impurities removed, 26.8 per cent. of the lead, 61.2 per cent. of the arsenic, and 28.1 per cent. of the antimony went off in the fume.

The results of these two runs check fairly well in the main. Both charges were about alike in impurities, excepting that charge B carried more lead. This was entirely accidental, since the pig was charged without any selection and represents conditions exactly as they existed. For comparison, the analyses of the two charges are set opposite each other in the following figures:

Average analysis of the copper as charged:

	Cu. Per Cent.	Pb. Per Cent.	As. Per Cent.	Sb. Per Cent.
Charge A, . .	93.9	0.676	1.38	0.40
Charge B, . .	93.1	1.27	1.37	0.42

Average slag-analysis:

	Cu. Per Cent.	Pb. Per Cent.	As. Per Cent.	Sb. Per Cent.
Charge A, . .	39.7	9.7	2.3	3.4 (?)
Charge B, . .	32.3	16.6	2.3	1.9

Per cent. of impurities removed from furnace in slag:

	Cu. Per Cent.	Pb. Per Cent.	As. Per Cent.	Sb. Per Cent.
Charge A, . .	1.97	67.1	7.7	39.6 (?)
Charge B, . .	1.5	58.8	7.6	19.8

Analysis of the anodes cast:

	Cu. Per Cent.	Pb. Per Cent.	As. Per Cent.	Sb. Per Cent.
Charge A, . .	96.36	0.15	1.15	0.33
Charge B, . .	96.0	0.26	1.15	0.32

Per cent. of impurities removed which went off in fume:

	Pb. Per Cent.	As. Per Cent.	Sb. Per Cent.
Charge A, . . .	11.82	12.82	?
Charge B, . . .	21.50	12.10	7.4

Extracted in furnace-refining:

	Cu. Per Cent.	Pb. Per Cent.	As. Per Cent.	Sb. Per Cent.
Charge A, . .	1.97	78.9	20.6	?
Charge B, . .	1.5	80.4	19.60	27.5

It will be noted that the refining has made the copper about 2.5 per cent. higher.

Comparison of slagging-coefficients (that of copper being assumed as unity):

	Lead.		Arsenic.		Antimony.	
Charge.	A.	B.	A.	B.	A.	B.
First slag, . .	28.0	33.4	3.5	5.5	17.3?	14.7
Second slag, . .	36.6	35.3	4.1	5.2	20.4?	12.9
Third slag, . .	37.2	34.0	4.3	4.5	20.2?	12.7
Fourth slag, . .	......	95.4	....	1.3	......	2.9

The slagging-rates are seen to hold about the same for any particular slag, but to decrease as the proportion of impurities decreases. Undoubtedly more slagging would have given a higher extraction of lead.

The greater volatilization of lead in charge B is undoubtedly due to more lead in the pig charged.

The above results are mainly of metallurgical, rather than of commercial, interest, since the quality of cathodes produced from this class of anodes does not vary noticeably when the fire-refining is carried further. While it would be interesting to learn the maximum extent to which lead, arsenic, and anti-

mony could be eliminated in such operations, the subsequent results achieved in the tanks did not seem to warrant the extra cost for fuel, furnace-repairs, danger to the furnace-bottom, extra labor, etc., involved in experiments for that purpose.

II. Electrolytic Refining.

The Influence of Soluble vs. Insoluble Impurities on the Purity of Electrolytic Copper.

The preceding section gives the results of fire-refining operations on very impure copper-bullion, undertaken in a 150-ton, Welsh type, reverberatory refining-furnace, in the endeavor to improve tank-house conditions for the electrolytic refining of this copper. In the present section, I hope to show that the impurities which are sometimes present in cast, electrolytically refined copper, in amount sufficient to impair seriously its conductivity, are there, not through electrolytic deposition, but entirely through the mechanical settling on the cathode, during its deposition, of suspended slime.

The data here presented are based upon observations of the working of the above-mentioned copper in the commercial tanks, both with and without much previous fire-refining, and comparisons drawn between this and the more usual grade of copper-bullion.

These results, taken together with earlier observations on floating slimes, have confirmed the belief, long entertained by me, that, with soluble anodes, it is the insoluble impurities of the slime, mechanically deposited during the cathode-growth, and not (as is generally believed) the soluble impurities of the electrolyte, electrolytically deposited, that cause the low conductivity of cast electrolytic copper, when the cathodes are deposited in an electrolyte of sulphuric acid, copper sulphate, arsenic, and antimony, of the degree of concentration usual in present practice.

In my opinion, electrolytes much more impure than is the present practice can be used with high-grade cathodes as a product. As will be seen from the figures following, good copper has been commercially made from electrolyte running as high in arsenic as 17.0 g. per liter, with copper sulphate at 144 g. per liter.

It is probable that most copper-refiners would believe the end at hand were they forced to use such an electrolyte; nevertheless, I noted no phenomena in connection with its use that would lead me to believe that the allowable limit of soluble arsenic was anywhere in sight. I do not mention antimony, since it can be shown that the electrolyte is soon saturated with that element, which thereafter goes entirely into the slime.

These experiments were discontinued early in 1910, when I resigned to take a position with another company; but I think the following record of them will establish my proposition.

From the well-known fact that slimes are high in impurities, it follows that a small amount of slime, settling on, and subsequently remelted with, the cathode, might add enough impurity to give a low conductivity in the resulting cast-copper.

We all know that arsenic is electrolytically deposited on the cathode from a solution depleted of copper sulphate; but an electrolyte thus depleted in copper sulphate should not be present in the commercial tank of a copper-refinery. This reaction, therefore, does not affect the present argument, except through the circumstance that copper-refiners may have different views as to what constitutes such a depleted solution; in other words, what is the lowest amount of copper sulphate in the electrolyte which will still give a good cathode-deposit.

With regard to this question, I think a depleted solution such as I have mentioned is one in which the concentration of copper ions is not sufficient to convey all the current to the cathode, under the existing conditions of current-density and solution-circulation. In that case, the current will seize upon the element present in the solution which stands next in the electro-chemical series. This happens to be arsenic; and the resulting deposition of arsenic in the cathode will give to the latter a lower conductivity. But it is not my present purpose to consider such a case. My argument proceeds on the assumption that the electrolyte is not depleted of copper.

Comparing the ratio of silver to arsenic and antimony in the average slimes, with the same ratio in the copper cast from cathodes deposited during the time the slimes were made, we find that this ratio is greater in the cast product. Heretofore, the inference has been that this additional amount of impuri-

ties must have been electrolytically deposited from the solution, and consequently that the greater the quantity of soluble impurities in the electrolyte, the greater their liability to deposition in the cathode. This conclusion is plausible; but, as I shall show, the solutions usual in copper-refining are relatively so pure that their impurities are a long way from beginning to deposit, and, therefore, measures taken to prevent their deposition are unnecessary as well as costly.

It is customary among copper-refiners, when the arsenic in solution rises seriously above 10 g. per liter, and it is impossible at the time to remove sufficient electrolyte to reduce it, to increase the proportion of copper sulphate over that usually carried, on the theory that the arsenic will then be less liable to deposit, and hence the conductivity of the cast-copper will be maintained. This also is a natural inference; but whether a higher concentration of copper sulphate is actually necessary or not, will depend on how nearly the electrolyte is "depleted" in this salt.

In my judgment, this increase of copper sulphate is, in general, not only unnecessary but positively disadvantageous, for the reasons: (1) that a further increase of copper sulphate increases the specific gravity of the solution, thereby giving slimes more chance to float to the cathode; (2) that, the higher the concentration of the copper sulphate, the more it acts as an oxygen-carrier, thereby aiding the acid in dissolving, chemically, more copper from the anode, with a consequent more rapid increase of the soluble copper in solution. To keep this amount within bounds requires either the removal of a part of the solution for the crystallizing-out of its copper, or the installation of insoluble anodes for the deposition of this excess of copper (both of these operations are costly, unless, in the first case, bluestone is made for the market, and even then there is liable to be a loss at present prices of that article); (3) that, as I believe, though I have not been able to prove it to my own satisfaction, a high copper-sulphate concentration tends to cause polarization on the anodes, thereby giving a larger amount of floating slime; and (4) that high copper sulphate in the electrolyte tends to cause a very coarse crystallization in the cathode-growth, thereby giving plenty of spaces for holding floating slime.

In testing the hypothesis that the greater proportion of arsenic and antimony to silver in the cast copper, as compared with the corresponding proportion in the slime, was due to the slime only, and not to electrolytical deposition, settled slime was collected at various points of the solution-circulation.

For the purpose of reducing all results to a comparable basis, the amount of arsenic and antimony per ton of slime has been compared in each case with that of the silver existing there, as so many avoirdupois ounces of arsenic or antimony to one troy ounce of silver, because silver is the only large and totally insoluble constituent of the slime.

The average analysis, for 15 weeks, of weekly composite regular slimes swept from the tanks shows:

Au. Oz. p. t.	Ag. Oz. p. t.	As. Per Cent.	Sb. Per Cent.
146.2	13,569	3.2	6.0

Ratio of gold to silver: 1 oz. Au to 93.0 oz. Ag.

Ratio of silver to arsenic and antimony: 1 oz. Ag to 0.076 avoir. oz. As, and 0.142 avoir. oz. Sb.

Slime which had settled in the return-solution launders, just outside the tanks, ran:

Au. Oz. p. t.	Ag. Oz. p. t.	As. Per Cent.	Sb. Per Cent.
54.93	6,130	5.3	13.0

Ratio of gold to silver: 1 oz. Au to 112 oz. Ag.

Ratio of silver to arsenic and antimony: 1 oz. Ag to 0.277 avoir. oz. As, and 0.680 avoir. oz. Sb.

Slimes collecting in a lead-fiber filter, just ahead of the pumps, gave:

Ratio of gold to silver: 1 oz. Au to 118 oz. Ag.

Ratio of silver to arsenic and antimony: 1 oz. Ag to 1.40 avoir. oz. As, and 1.34 avoir. oz. Sb.

Slimes escaping the filter and settling beyond it, but before reaching the pumps, ran:

Ag. Oz. p. t.	As. Per Cent.	Sb. Per Cent.
3,235.6	8.0	26.5

Ratio of silver to arsenic and antimony: 1 oz. Ag to 0.794 avoir. oz. As, and 2,620 avoir. oz. Sb.

Slimes settling in the section-boxes, just before the solution entered the first electrolytic tanks on its return, and therefore representing the lightest float-slime that it was possible to catch—since it had completed the solution cycle—gave:

Au. Oz. p. t.	Ag. Oz. p. t.	As. Per Cent.	Sb. Per Cent.
71.57	471.0	16.0	33.8

Ratio of gold to silver: 1 oz. Au to 6.6 oz. Ag.

Ratio of silver to arsenic and antimony: 1 oz. Ag to 10.87 avoir. oz. As, and 22.91 avoir. oz. Sb.

From these figures it appears that the longer the slime floats, the higher the amount of arsenic and antimony it contains, running from 0.076 avoir. oz. As and 0.142 avoir. oz. Sb per troy oz. silver in the slime falling in the tanks, to 10.87 avoir. oz. As and 22.91 avoir. oz. Sb per troy oz. Ag in the lightest float, or an increase of arsenic of 142 times, and of antimony of 161 times, that in the main bulk of slime for the same silver-content. (These figures may serve also to give some idea of the degree of fineness of the gold-particles, since, in the slime floating longest, there is, for the same silver-content, five times as much gold as in the main bulk of the slime, notwithstanding the fact that gold is 1.83 times as heavy as silver.)

Naturally, the amount of slime-float passing any given point is smaller the farther this point is from the source of production. Hence it would be entirely in order to assume that if mechanically-deposited slime, instead of the solubles in the electrolyte, were responsible for the copper-refiner's troubles, the excess of impurity over silver in the cast product, above that in the main bulk of the slime, should be accounted for by the impurity in the first float-slime caught. Moreover, since the main bulk of the slime must have fallen directly from the anodes to the bottom of the tanks, it could not rightly be classed as float, and could not have remained suspended in the solution long enough to settle in any great amount on the cathode.

If these assumptions are correct, we may naturally expect to find the ratio of silver to arsenic and antimony in the first float similar to that in the cast product. Within the reasonable limits of error to be expected in dealing with lots of com-

mercial size, and with small percentages of impurity, this conclusion is confirmed by the following figures.

The average analysis of the wire-bar cast during a period of three months shows gold, silver, arsenic, and antimony as follows:

Au. Oz. p. t.	Ag. Oz. p. t.	As. Per Cent.	Sb. Per Cent.
0.0116	1.833	0.00162	0.00171

Ratio of gold to silver: 1 oz. Au to 110 oz. Ag.

Ratio of silver to arsenic and antimony: 1 oz. Ag to 0.282 avoir. oz. As, and 0.298 avoir. oz. Sb.

These figures compare very closely with the ratios obtained from the analyses of the first float-slime; and, ignoring the consideration of what lighter and more impure float might be caught on the cathode before leaving the tank, the impurities in the wire-bar can be entirely accounted for by the first and heaviest float. I may explain here that by the word "float" I mean the slime either floating on or in the solution, as distinguished from the slime which settles directly, upon being detached from the anode.

While the figures given above seemed to establish my hypothesis, they did not furnish answers to all objections. But, about a year later, further opportunity of investigation was given by the very impure copper-bullion mentioned at the beginning of this paper.

For a long time, this bullion had been treated by mixing it in small proportion with purer copper; but the results were not at all satisfactory, and the resulting cast-copper was liable to be low in conductivity. In trying to overcome this evil, and starting from the foregoing hypothesis, that the insoluble slime, rather than the soluble constituents of the electrolyte, was the source of the final trouble, I had this impure pig charged by itself into the anode-furnace, with the purpose of refining it there as far as possible, and then further refining it electrolytically in a separate electrolyte. I reasoned that, treating this bullion by itself, we would get better cathodes from the usual grade of anodes, and that the cathodes made from the leady anodes could either be cast into separate ingots of inferior quality, or mixed before casting, in predetermined proportion, with the material furnished by the better cathodes.

As the experiment had to be finally performed, there was only enough of this impure copper to supply about three-fourths of the tanks set aside for this separate circulation. The rest had to be loaded with the purer anodes. Yet, in spite of this interference of commercial requirements with purely scientific investigation, the results were significant.

As a consequence of the large proportion of very impure copper present, the electrolyte increased very rapidly in arsenic, in spite of large daily removals of solution, until, at the time the experiments were stopped, it held 17 g. of arsenic per liter. Yet, in every case, the copper cast from the cathodes taken from tanks loaded with good anodes was above the standard in conductivity. In appearance, these cathodes were in all cases similar to those deposited in other and purer solutions from the same grade of anodes. But cathodes taken from the tanks loaded with leady anodes were very dirty with slime, and, even when washed and carefully scrubbed, were only fit for low-conductivity ingots.

Two furnace-charges of cathodes deposited from good anodes in high-arsenic solution were taken for observation. They were in every way representative of all the others, and therefore will serve as examples. They will be designated as charge X and charge Y.

Charge X contained 64 per cent. of the above class of cathodes, the balance being cathodes from the same class of anodes, deposited in a solution carrying about 9 g. of arsenic per liter.

Test-wires for conductivity taken from this charge after the 1st, 3d, and 5th sixths had been cast, gave 97.3, 97.7, and 97.0 per cent. of conductivity, Mathiessen standard, hard drawn. The silver in the cast copper was 1 oz. per ton. The average analysis of the electrolyte in grams per liter, during the two weeks in which this copper was depositing, was

Sp. Gr.	Free Acid.	Copper Sulphate.	As.	Sb.	Cl.	Ni.	Fe.
1.210	123	133	15.3	0.50	0.025	17.9	2.2

The anodes from which this 64 per cent. was deposited analyzed :

Au, 1.76 oz. p. t.; Ag, 288.0 oz. p. t.; Pb, 0.05; Cu, 97.92; As, 0.16; and Sb, 0.19 per cent.

Charge Y contained 72 per cent. of this class of copper; and

wires drawn from samples taken as above ran 97.3, 97.4, and 97.4 per cent., respectively, Mathiessen standard, hard drawn. The silver in the cast copper was 0.8 oz. per ton. The average analysis of the electrolyte in grams per liter, during the two weeks in which this copper was depositing, was

Sp. Gr.	Free Acid.	Copper Sulphate.	As.	Sb.	Cl.	Ni.	Fe.
1.215	109	144	17.0	0.50	0.026	17.9	2.20

The anodes making this 72 per cent. closely approximated those of charge X.

The balance of the charge was of cathodes from the same grade of anodes, but deposited in a solution averaging in the neighborhood of 7.5 g. of arsenic and 12.3 g. of nickel per liter, the other salts being about the same as in the above solution.

Undoubtedly it would have been better to make the above charge entirely of cathodes deposited in the more impure solution; but this was not possible at the time, since the furnace-charge was 125 tons, and operating-conditions would not permit us to hold this copper back. In general appearance, however, there was no difference between the cathodes deposited in the different solutions.

From the above figures it would appear that the soluble impurities in the electrolyte, in amounts up to those last shown, do not affect the purity of the deposited copper to any greater extent than do those in a purer electrolyte, since the conductivity of the copper cast from cathodes deposited in an impure solution was in no way inferior to that of copper cast from cathodes deposited in a purer electrolyte from anodes of the same grades.

The following results also confirm the theory, in so far as it has been tested with impurities to the amount above given.

When cathodes were being taken from a section of 34 tanks which had been loaded with the impure, leady anodes, a cathode was picked out which was a very good representative of all the rest. All the cathodes were extremely dirty.

A wire directly drawn from this representative cathode gave a conductivity of 99.3 per cent., Mathiessen standard, hard drawn, and a tensile strength of 61,200 lb. per sq. inch.

The average analysis of the electrolyte in grams per liter, during the time this copper was depositing, gave:

Sp. Gr.	Free Acid.	Copper Sulphate.	As.	Sb.	Cl.	Ni.	Fe.
1.210	113	131	16.6	0.50	0.022	17.9	2.2

Had any of this arsenic been deposited electrolytically on the cathode, it would be in such combination as to affect the conductivity of the wire very considerably. This was not the case.

The entire lot of these cathodes was cast into ingots, forming 97 per cent. of the charge so cast. The conductivity of the copper, as given by samples taken after casting the 1st, 3d, and 5th sixths of the charge, was 94.4, 94.9, and 94.4 per cent., Mathiessen standard, hard drawn. The copper plus silver in the ingots was 99.946 per cent.; and the silver was 3.8 oz. per ton.

It should be remarked that, before charging into the furnace, these cathodes received a thorough scrubbing with brush and water, and were treated in the furnace so as to remove as much of their impurities as possible.

Analyses were made as follows:

	Au. Oz. p. t.	Ag. Oz. p. t.	Cu. Per Cent.	Pb. Per Cent.	As. Per Cent.	Sb. Per Cent.	Ni. Per Cent.
Ingots......	......	3 8	99.946	......	0.0040	0.0048	0.0046
Cathode...	......	0.9	......	......	0.0016	0.0019	0.0028
Slimes	25.8	5434.2	8.6	22.5	6.8	11.8	5.8
Anodes ...	0.83	213.9	96.59	0.65	1.00	0.32	0.2044

The anode-sample was a composite of two samples taken during the time the anodes were cast; the slimes-sample was taken from the same tank as the cathode.

If arsenic, or other impurity, in the electrolyte, had been deposited electrolytically on the cathode, all portions of the latter should have been equally affected. Working on this basis, and endeavoring to eliminate, as far as possible, all superficially-adhering slime, we cut out a piece near the top of the cathode and about 5 by 8 in. in size, and thoroughly washed the surface with dilute nitric and then with dilute sulphuric acid. This should leave in the sample only: (1) those impurities which had mechanically settled on the cathode during its deposition, and had been covered by copper subsequently deposited; and (2), the impurities electrolytically deposited from the electrolyte. The piece was sawed to destruction, and the sawdust was taken for analysis. The result of this analysis is given above under the heading "Cathode."

Since there is no soluble silver in the electrolyte, all silver found in the cathode must have come from settled slime; and

on the supposition that all slime-impurities followed the silver mechanically on to the cathode, in the same ratio as that presented in the slime, the above cathode-analysis would show as follows:

	Ag. Oz. p. t.	As. Per Cent.	Sb. Per Cent.	Ni. Per Cent.
Cathode, . .	0.9	0.00113	0.00195	0.00096

Especially as regards arsenic and antimony, these figures check very closely with the actual analysis, even though the calculated analysis does not take into account the influence of the heavy float, which must have been considerable in amount, as shown by the extremely dirty condition of the cathodes. The influence of such float has been shown in a former part of this paper. It is evident that little, if any, room is left for the recognition of electrolytically deposited arsenic or antimony.

The foregoing results show, I think, that such impurities as are found in cast electrolytic copper are due to mechanically held slime and not to impurities electrolytically deposited from solution.

It is when impurities from alloys are formed with the copper that they affect its conductivity; and my experiments with the cathode show that such alloys must be made subsequently in the ingot-melting furnace, by the chemical union, through fusion, of the mechanically-held slime with the copper of the cathode, and that they were not made by electro-deposition from the solution.

How high the arsenic may be allowed to go in solution in the electrolyte (copper sulphate and acid remaining the same), before it will begin to be deposited, I am not prepared to say. It seems, however, that arsenic does not begin to be deposited up to 17 g. per liter with copper sulphate in the neighborhood of 140 g. per liter; and it is probable that the allowable amount of soluble arsenic may be increased very considerably over that now carried in usual commercial electrolytes, without running any risk of impairing the conductivity of the product.

It must also be borne in mind, however, that the slimes must be kept off the cathode, and that the less they settle there the purer will be the resulting copper.

In present practice, when there is anything wrong with the conductivity of the copper, it seems to be usual to seek a remedy by altering the electrolyte. This appears to me to be

looking in the wrong place for the evil to be remedied. In my judgment, it is generally the preliminary refining, and the consequent quality, of the anode which chiefly need attention. These adjusted properly, the slimes will be heavy and will not cling to the anode; and, as a consequence, a higher percentage of impurity will fall at once out of the metallurgical calculation; there will be less "float"; and the result will be purer cathodes. I am thoroughly convinced that, in comparison with these requirements as to the anode, there is a great leeway in the composition of the electrolyte.

Summary.

1. The impurities in cast electrolytic copper are present in about the same proportion as they exist in the heaviest float-slime, and are there because of that float.

2. The conductivity of copper cast from cathodes deposited from good average anodes in an electrolyte containing arsenic in amount up to 17 g. per liter, is as good as that of copper cast from cathodes deposited from the same grade of anode in a solution containing not more than 8 g. of arsenic per liter.

3. The wire drawn from a cathode representing 34 tanks of dirty cathodes deposited from high-arsenic, leady anodes in a solution containing 17 g. of arsenic per liter, gave a conductivity, hard drawn, of over 99 per cent., Mathiessen standard, whereas these same cathodes melted and refined in the furnace gave a conductivity, on the same basis, of less than 95 per cent.

4. The analysis of impurities known to be held wholly in the cathode—*i. e.*, none of which adhered to the surface—has shown that they were present in practically the same proportions as they exhibited in the slimes, and therefore must be due to mechanically-held "float." It follows that the copper itself must have been deposited as pure copper; and this is confirmed by my last paragraph, since only very pure copper would give a hard-drawn conductivity-test of over 99 per cent., Mathiessen standard.

5. When the percentage of anode-impurities going to slime is calculated, some interesting facts appear. According to the figures given above, all the lead, 26.7 per cent. of the arsenic, all the antimony and all the nickel went to the slimes. That this is the usual thing with anodes of this class, can readily be shown. The natural expectation would be that the nickel

would go into solution as nickel sulphate; and so it does, to a certain extent. Its appearance in the slime can very probably be accounted for by the fact that nickel and arsenic have a considerable affinity for each other, and form a speiss which is insoluble to the electrolytic corrosion. The surplus of nickel does go into the solution; and it is well known that practically all commercial electrolytes carry nickel.

The large difference shown between the calculated and the observed values of nickel in the cathode, is a mystery which I have been prevented from investigating.

Discussion.

Albert R. Ledoux, New York, N. Y.—I can add a little to the information which has been given, by saying that it has been our business for some years, among other things, to inspect outgoing copper from some of the works here in the East, and to find out why there were variations not only in the conductivity of the wire-bars, but also in the character of the cathode-copper shipped; and we have found two things: These impurities which have been mentioned are largely upon the surface of the cathode. Samples taken of the inside, even of the nodules or "berries" which grow on the outside of the cathode, show that they do not contain more impurities than the denser material in the interior. In other words, it is a superficial deposit or contamination. There is still another reason for impurity in some of the copper which finds its way to the manufacturers, namely, carelessness in the handling of molds or in casting. We have found copper which was comparatively pure, as far as the copper itself was concerned, but contained, mechanically intruded in the interior of the ingots, cakes, or wire-bars, impurities which would lower the quality of the whole.

As a fact bearing on that, I may say that we have noted in our laboratory, within the last few days, some interesting points in connection with experiments which we have been making. A very large manufacturer had had some shipments returned to .him because the metal would go to pieces under stress or friction; would flake off or break along certain lines when in use. Analyses of samples of the metal, taken by boring through the whole mass, did not show any appreciable

impurity. Nevertheless, there was this flaking off; and we were asked to ascertain the cause. By planing down some of the metal, we found layers or streaks of dark material, which was proved, both by analysis and by microscopic tests, to consist of graphite. We learned that the molds had been made in damp sand and then lined with graphite. But the graphite was found later in the interior of the casting, not on the outside —a fact which puzzled us for a long time. We think we have hit upon the explanation: that the heat of the molten metal turned into the mold generated steam in the wet sand; that this steam had no means of escape except towards the surface, and found its way up through the metal, carrying along, mechanically, a part of the lining of the mold.

I am tempted to tell of two other experiences, showing the difficulties under which the most scientific managers of electrolytic plants sometimes labor.

Some years ago, the head of one of the most important electrolytic refineries in the United States was puzzled to discover the cause of certain short-circuits. He noticed that an accretion started at the anode and grew always from one side of the anode towards the cathode until it had completed a short-circuit. The works ran north and south, and this short-circuiting was always from the west towards the east. The manager came very near making a statement before a scientific society that the revolution of the earth must have something to do with this short-circuiting, as it always was in the direction from the west towards the east; but one day he broke off one of these fingers, which ran across, and found, at the point where it began, a little splinter of wood. He broke off others and found the same thing; and, to make a long story short, the reason was just this: The anodes, which were heavy, were brought into the factory, unloaded from a car, and dumped by the men on a block of wood alongside of the tank. They did it always the same way; the corner of the anode always struck the wood at a certain inclination, and little splinters of the wood were broken off, and adhered to the bottom of the anode. When the anode was put into the tank (always in the one way), that splinter served as a starting-point for a short-circuit, and that was the simple solution of something that had been bothering them for more than a year. When they substituted a rubber mat for a wooden block, the trouble ceased.

But not all the difficulties of owners of electrolytic refineries are due to such accidents We were retained some years ago by the owners of a large plant to ascertain what became of their extraordinary silver-loss. They analyzed very carefully their ores and the products which went into the electrolytic refinery. They kept very close watch of all the operations, and yet there were losses in silver which they could not locate. The technical man in charge of the electrolytic refinery claimed to possess certain secrets, employed in the process; and it was agreed in his contract that no one should be admitted into the room where the purifying of the electrolytic solutions took place under his sole charge. By the way, we were told that he also put something into his tanks, which he bought himself, and kept as a secret. We succeeded in getting hold of some of the material and found it was nothing but anilin green. It gave a brilliant color to the solution; that was all.

We became convinced in our investigation that there was something wrong with the purifying-room; that the silver that went into it did not come back into the tanks. We took some men one night and dug a trench around the end of the house, on the side towards the town sewer. We discovered the original solution running down this sewer! The secret processes of purifying consisted in part, at least, in wasting this valuable solution, containing very large quantities of silver. Of course he could make his solution pure by renewals, and after letting the foul solutions run to waste in the sewer and carry silver with them; and that is where the loss in silver came in in that particular refinery.

Dr. Raymond (in reply to a question): Mr. Emrich does not say how he proceeded in separating and drawing into wire a sample of the cathode to which he refers as giving, under that test, a high conductivity. He speaks of the impurities as mechanically deposited in the cathode, and sometimes as being laminated. He is talking about a laboratory specimen, and I suppose he took a small piece which was apparently free from impurities.

Dr. N. S. Keith: We know that electrolytic deposits are not of a strictly reguline character; they are simply agglomerations of minute crystals. How coherent they are has not been determined. Attempts made to work such copper, without

heat enough to cause fusion and form alloys of copper with the materials inclosed between the crystals, have been unsuccessful for producing metal to be drawn into wire.

The statement of Mr. Emrich, that frequently, from various causes, wires drawn from the wire-bars made by the fusion of such cathodes possess less conductivity than is commercially desirable, is undoubted; and it is most probable that impurities, like arsenic, sulphur, antimony, etc., carried over mechanically by agitation of the electrolyte, have contaminated the original cathodes. Various efforts have been made to prevent this transfer, such as inclosing the anodes in bags, to act as screens; but hardly any bag we can make for practical use will prevent the passage of exceedingly minute particles which will float in the electrolyte, in which they may be present, even when the solution looks perfectly clear. I learned that from my own investigations some years ago, and I also found that if the electrolyte in direct contact with the cathode contains copper enough, then, under proper intensity of current, copper will be deposited without the other metals. If the voltage rises somewhat, and if there is a deficiency in the amount of copper ions in direct contact with the cathode, then hydrogen is deposited with copper, because it is the most prevalent ion in the solution, and will be occluded in the exceedingly minute interstices between the crystals of the deposit. Agitation of the electrolyte is necessary to replace continually the solution which, in immediate contiguity with the cathode, has become depleted of copper, by solution containing the normal amount of copper ions. Hence, the minute floating particles of slime might also be included in the cathode through mechanical deposition.

The important question is, What improvement in practice may come from these observations? Mr. Emrich's production of good wire from a specimen of a bad cathode is, of course, not a proof that such cathodes can be separated in practice, without melting, into good copper and impurities. What he argues is that the impurities in such cathodes are mechanically mixed and not alloyed; hence, that they are not due to the electric deposition; and, therefore, that their source is the anode, not the electrolyte, and that remedies must be sought in the direction thus indicated. His observations should certainly be tested in the research-laboratories of our great electric refineries.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Electrostatic Concentration or Separation of Ores.

BY HENRY A. WENTWORTH, BOSTON, MASS.

(New York Meeting, February, 1912.)

ELECTROSTATIC separation of ores in its present form is generally known as the Huff process from the name of Charles H. Huff, of Boston, Mass., through whose constant and persistent labors (with the invention of Clinton E. Dolbear as a basis) the successful commercial process embracing separative machinery and the various electrifying devices has been developed step by step, and the finances for the long period of development provided, and the method finally established and recognized throughout the world as an important and successful addition to the ore-dressing department of metallurgy.

The permanent field-success of electrostatic separation began in 1908 with a 20-ton Huff experimental mill built specially for the purpose by the American Zinc, Lead & Smelting Co., in Platteville, Wis., a plant which was a success from the start and was gradually increased in capacity as the market-conditions warranted to 100 tons of concentrates per day. Much credit is due to the above-mentioned company for its initial venture, and for its assistance in applying the process to field use.

Prior to 1908 electrostatic separators had been installed and operated (but for a comparatively short time, however) in a number of places; some under the patents of Mr. Dolbear by himself and associates, and some under the patents of Lucien I. Blake and Lawrence N. Morscher, by W. G. Swart, mining engineer, of Denver, who has always been a courageous advocate of electrostatic separation.

Due to the difficulties experienced in the generation of the electrical charges, the primitiveness of the separators, the wooden construction instead of iron as at present, the lack of control of the electrical fields and other difficulties overcome by the later inventions of the Huff Electrostatic Separator Co.,

electrostatic separation did not gain favor during those early field-endeavors.

There is an old experiment in physics where an electrified rod is brought close to a suspended pith ball. The pith ball is first attracted, clings for a moment to the rod, and is then vigorously repelled. As the rubber rod approaches the pith ball, a charge of opposite kind, so called, is induced on the side of the pith ball nearest to the charged rod, and as unlike charges of electricity attract one another and as the pith ball is very light, it moves to the rubber rod. But pith, though not a good conductor of electricity, does, because of the moisture contained, conduct electricity appreciably, and it soon becomes, as a whole, charged similarly to the rubber rod, and away it flies. This is the principle which is utilized in electrostatic separation, and to accomplish separation, the differential property is the conductivity of the minerals involved. Thus, if the circuit of an ordinary 110-volt incandescent lamp is broken, and a piece of pyrite inserted in the break, the current will again flow. Similarly, if a piece of quartz be used, the electrical circuit will remain broken. Between these extremes, the conductivities of minerals grade, there being, however, a great difference in conductivity between the so-called better conductors and poorer conductors.

The physical separation may be accomplished in several ways, all utilizing the same underlying principle of difference in conductivity of the minerals. In the simplest form, a mechanical mixture consisting of readily-conducting and poorly-conducting minerals (such, for example, as grains of copper and grains of sand) is dropped on to a metallic plate charged to a high potential. Immediately upon contact with the plate the better-conducting minerals become charged to the potential of the plate, and are thrown vigorously from it. The poorer conductors require a much greater time to reach the electrical condition of the plate, and therefore, if they are not given time to reach this condition, due to being removed from the plate, a separation is obtained. This method was utilized in the simplest form of electrostatic separator, as illustrated in Fig. 1, in which the charged plate is replaced by an electrified roll.

Wherever there is electrical repulsion, there must be an electrostatic field (analagous to a magnetic field), with two ter-

minals to the lines of force. Just as a magnetic particle endeavors to move along the magnetic lines of force, and would were there no other forces acting, so an electrified particle endeavors to move along the electrostatic lines from one ter-

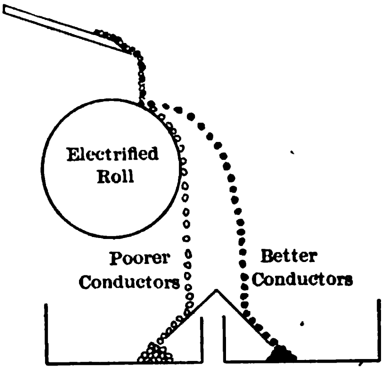


FIG. 1.—SIMPLEST FORM OF ELECTROSTATIC SEPARATOR.

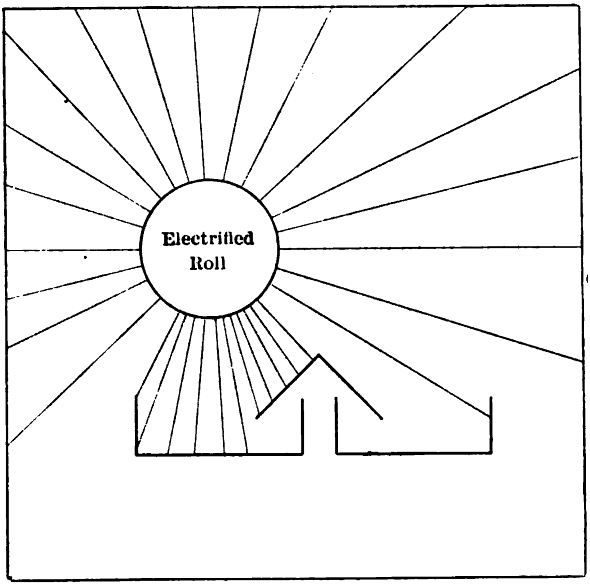


FIG. 2.—LINES OF ELECTROSTATIC FORCE.

minal of them to the other. In the example just cited, the charged surface is at one terminal of the lines, while the walls of the room are at the other, the electrostatic lines existing as is shown in Fig. 2.

The particle charged from its contact with the metallic roll, may be said to be repelled from the roll, or attracted to the walls of the room.

Suppose now instead of permitting all of the lines to pass to the walls of the room, they are concentrated to another roll, as shown in Fig. 3, by connecting opposite terminals of the charging-device to the two rolls. The field is now much more localized and intense than in the case of the disseminated field of Fig. 2.

However, instead of depending solely upon the removal of the poorly-conducting particles from the surface of the charging-body before they have time to become charged, the length of time during which the metal surface remains charged may be regulated, as the better-conducting particles obtain their charges practically instantaneously upon contact.

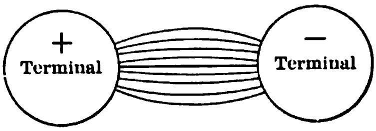


Fig. 3.—Concentration of Electrostatic Field.

Still another method of applying and utilizing the charge may be used. It has long been known that from points or sharp edges of conductors, when charged to a high potential, there emanates an electrical spray, which consists of charged air passing from the point or edge to the surface of opposite potential. Assume now there are passing over the roll a number of grains of good conductors and poor conductors, as illustrated in Fig. 4. The charged air traveling from the point to the roll will strike upon the backs of these particles which are in contact with the roll and deliver charges to the particles. In the case of good-conducting particles this makes no difference, as the charge is immediately transferred from each particle to the roll with which it is in contact; but with the poorly-conducting particles the charge leaks away but slowly to the roll, with the result that the charges on the roll and on the backs of the particles are different, and the particles are held firmly to the roll until the charge leaks away. Assume the roll is grounded. The charges on the

backs of the poorly-conducting particles induce charges on the face of the roll near them, and the endeavor of the two kinds of charge to unite holds the particles closely and tightly to the roll. When the roll has made a partial revolution the particles are removed by a brush, while the differently conducting minerals may be separated by the use of gravity or centrifugal force.

For years these various methods of application of the principle have been studied, and a process developed to combine the applications in the manner which seemed to give the best results in the field under the conditions of mill-practice. It should be borne carefully in mind that in all the cases above cited the separative effect is accomplished by taking advantage of the difference in electrical conductivity of the particles.

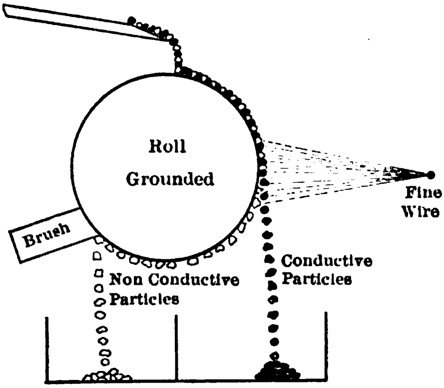
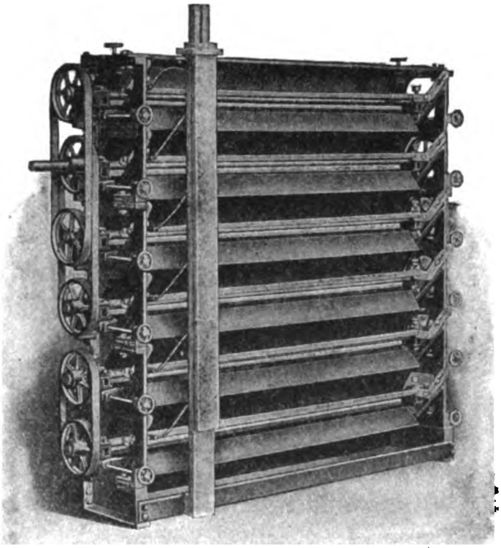


FIG. 4.—CHARGES DELIVERED BY ELECTRIC SPRAY.

Several types of Huff separators have been developed for application to different materials. The following description is of two types only—those in most common use and most generally applicable. A type consisting of six separating-fields and a feeder is illustrated in Fig. 5, which does not, however, show the large feed-hopper and the heavy base. The entire machine, with the exception of the attracting-rods and their supports, is made of metal, and is electrically grounded, so that all portions which come in contact with the ore are metal, and all parts with which the operator is likely to come in contact are grounded so that the operator gets no electric shocks in touching the machines. As it is desired to pass a thick sheet of ore

through the separators, there is more or less interference of particles at each separating-roll; hence it has been found advisable to use several rolls in succession, each contributing a part towards the complete separation. This is especially necessary in those cases in which it is desired to keep the ore coarse at the beginning, and thus have many attached particles to be reground. In order to have all the metallics come in contact with the separating-surface, a number of contacts at different angles are required. In this machine, the only moving parts are seven steel rolls revolving in babbitted and greased bearings, so that the power necessary to drive the separator itself is extremely small.



- I UFF ELECTROSTATIC SEPARATOR WITH SIX SEPARATING-FIELDS.

Fig. 6 is a diagrammatic sketch of a second form of separator, which is finding excellent favor in the separation of washed zinc-iron middlings below 20-mesh, which flow very readily. The advantage of this type is that there are no moving parts whatever, except the feed-roll, and therefore there is a minimum of wear and required power. Not all material, however, will flow sufficiently freely without external assistance to be applicable to this type of separator.

The size of particles which can be successfully treated by the present forms of Huff machines is from 6- or 8-mesh down to the limit of granularity of the material. Those slimes which are so cohesive that they do not move uniformly over inclined chutes cannot as yet be successfully handled. It is possible that this difficulty can be overcome by a special design of feeder or separator. In Utah a table-middlings is being treated wherefrom the impalpably fine material has been removed during wet-table treatment. However, of that portion going to the "C" (finest size) machines, all of which is through 80-mesh (aperture 0.0082 in.), 20 per cent. passes a 240-mesh (aperture 0.0020 in.) screen. Huff machines have been built

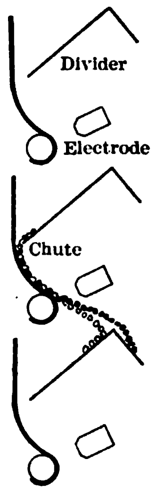


FIG. 6.—DIAGRAMMATIC SKETCH OF ANOTHER FORM OF HUFF SEPARATOR.

to handle material much coarser than 6-mesh, but up to the present the demand for such a machine has not warranted the investigation necessary to develop it completely.

The action produced in the usual type of electrostatic separator consists in electrically giving the relatively conductive particles a horizontal component of motion in addition to the motion produced by gravity. The less conductive particles, not being thus affected, are acted upon by gravity alone. The heavier the conductive particle, the stronger must this repellent force act to cause it to fall on the outer side of the divider of the machine. The repellent force is dependent upon the intensity

of the electrostatic field. As electrostatic separation treats particles varying greatly in size, therefore, with a field sufficiently strong to repel the very heavy particles, there is danger of the finer less conductive particles being thrown over also. Hence it is advisable not to have a feed in which the particles are too widely diverse in size, and therefore in weight. In practice the feed is screened into a few sizes, of which screening the following is an example: from 8- to 12-; from 12- to 20-; from 20- to 50-, and through 50-mesh. When the difference in conductivity of the minerals is small, it is sometimes advisable to size somewhat more closely.

At this point attention is called to a matter which properly belongs later. Crushing some varieties of ore to 10-mesh, for example, will expose practically all the mineral, but will free but little of it. Because of the numerous separation-fields to which the material is subjected while passing through the separator, all sides of every particle are brought into contact with the charging-surface, and nearly every particle which contains an appreciable portion of exposed mineral will be repelled, thus eliminating the rock as coarsely as possible. All the mineral can be thrown into a concentrate, or the better part into the concentrate from the first two or three rolls, and the balance into a middlings for recrushing.

The question of the electrification of the separators in a manner which should not be affected by varying atmospheric conditions was a serious problem at the beginning of the electrostatic development. The frictional or induction generators are in themselves exceedingly susceptible to changes of humidity of the atmosphere, and also their capacity is so small that any source of electrical loss on the line or in the separators is likely to throw the whole system out of adjustment. It is unfortunate that this difficulty should have been so widely advertised in the earlier stages of the work in connection with the "Blake" machines. It has restrained many from investigating the Huff machines. There is no longer any difficulty whatever from this source, the machines being adaptable, if properly installed, to any climate or any atmospheric conditions. The electricity is furnished the Huff machines by electromagnetic generators instead of frictional machines. These generators work as independently of atmospheric condi-

tions as does the ordinary lighting-dynamo, and are capable of supplying any line- or machine-losses which may occur and yet hold the potential absolutely the same from day to day. Contrary to general belief, the difference of potential which is used in electrostatic separation is only from 18,000 to 25,000 volts, instead of about 100,000 volts, earlier supposed to be necessary. There has been developed a small, compact, 3-h-p. electrical set, which is sufficiently large to care for the requirements of a 100-ton mill, and probably a much larger plant. Protective devices are placed between the generators and the separators to prevent injury to workmen in case of accident at the separators or accidental contact with the high-potential line. In the four years of its field-operation, no one has been injured from this source.

As the effectiveness of any electrostatic separation depends on the differences in conductivity of the particles, it follows that there must be no extraneous factor interfering to affect the conductivity. Water, is in the sense of electrostatic separation, a good conductor. Therefore the particles must be dry. Some minerals dry very readily and remain so. Some are hygroscopic, and if allowed to stand cold for some time in a moist atmosphere, tend to collect on their surfaces an extremely thin film of moisture. However, experience has shown that by properly constructing the mill equipment so that the ore from the drier passes immediately through its various paths, and is not permitted to lie for some time cold, and exposed to the atmosphere of a room, very few minerals, and none of the common ones, offer any serious difficulty from this stand-point.

There seems to be a very erroneous idea of the cost of drying ore. Crude mine-ore will run from 1 to 5 per cent. of moisture; 3 per cent. being a fair average. This means 60 lb. of water to be evaporated from each ton of ore. A fairly-efficient drier will expel from ore carrying 3 per cent. of moisture, 5 lb. of water per pound of coal, or, say, 12 lb. of coal per ton of ore. With coal at $5 per ton, this means a fuel-cost of $0.03 per ton. Fine middlings from water-tables will sometimes carry as high as 15 per cent. of moisture, and the fuel-cost is therefore increased under those circumstances to 10 or 11 cents per ton with the $5 fuel-cost, as with the higher per cent. of moisture the evaporating-power goes up to 8 lb. of water per pound of coal.

With regard to the minerals and their conductivities, as stated previously, the condition is entirely relative, some minerals being better conductors than others. However, the minerals may be divided quite closely into two classes: one, those which are very easily charged and repelled, and the other, the very poor conductors which act as non-conductors. A complete list of the conducting minerals has been compiled by G. W. Pickard. Table I. presents the more common of both classes.

TABLE I.—*Conducting and Non-Conducting Minerals.*

IMPORTANT CONDUCTIVE MINERALS.

Argentite,	Galena,	Psilomelane,
Arsenic, Native,	Graphite,	Pyrargyrite,
Arsenopyrite,	Hausmannite,	Pyrite,
Bismuth, Native,	Hematite,	Pyrolusite,
Bismuthinite,	Ilmenite,	Pyrrhotite,
Bornite,	Jamesonite,	Redruthite,
Brookite,	Leucopyrite,	Silicon,
Calaverite,	Linnaeite,	Smaltite,
Carborundum,	Magnetite,	Sperrylite,
Cholcopyrite,	Manganite,	Stannite,
Chalcocite,	Marcasite,	Stephanite,
Cobaltite,	Mercury, Native,	Sylvanite,
Copper, Native,	Millerite,	Tellurium,
Covellite,	Molybdenite,	Tetrahedrite,
Enargite,	Niccolite,	Wad,
Ferrosilicon,	Pentlandite,	Wolframite,
Franklinite,	Proustite,	Zincite.

POORLY-CONDUCTIVE MINERALS.

Zinc-Blende,	Epidote,	Apatite,
Quartz,	Garnet,	Rutile,
Feldspar.		

Nearly all the silicates, carbonates, and sulphates.
Most of the siliceous rocks.

There are a few important minerals whose conductivity is variable, being dependent upon the composition of the particular specimen. Among these are notably blende and garnet. Pure sphalerite is a very poor conductor, ranking among the best insulators. It seldom occurs pure, however, but is usually contaminated chemically by varying amounts of iron sulphide or manganese sulphide. When these impurities are present in very large quantity in the blende, the resulting mineral is commonly called marmatite. The behavior of blende in electro-

static separation is somewhat dependent upon the amounts and character of impurities in the mineral. Small amounts of iron or manganese, and sometimes up to several per cent. of these impurities, have no seriously deleterious effect upon the behavior of the blende, but when the impurity is present in sufficient amount the resultant mineral changes over into the class of conductors. The relation of impurity and conductivity seems to follow no definite law, but each sample must be examined independently. From the above, however, it is readily seen that it is theoretically impossible to produce the same grade of finished blende-product in any manner from all samples of ore. Whereas the Joplin or Wisconsin blende crystals will analyze from 66 to 67 per cent. of zinc, those of some regions when mechanically free from all impurity contain only from 40 to 45 per cent. of zinc, and perhaps from 10 to 20 per cent. of iron. As a rule, electrostatic separation is very successful in separating the zinc-minerals from other minerals.

Similarly, the conductivity of garnet is sometimes dependent upon the amount of iron present. A high-iron garnet is likely to be more conductive than a low-iron garnet. A study of the data in Table I. will show the general field for electrostatic separation or concentration.

Considering a few specific problems and the specific reasons for the peculiar adaptability of the Huff process to these problems, it should be noted, as shown in Table I., that most of the copper sulphide minerals are excellent conductors, while most gangue-rocks are poor conductors. Therefore, electrostatic separation is applicable to the general concentration of the sulphide ores of copper. It is particularly well-adapted to the concentration of copper-minerals from the heavier gangue-minerals, such as garnet, epidote, barite, the heavy basic rocks, etc. Large bodies of ores of this character exist, usually as altered contact-deposits, though, except in cases where the grade is sufficiently high for direct smelting, they have been developed but comparatively little, because difficulty has heretofore been found in concentrating them.

Often a combination of methods is more efficient than a single process, the governing factor being whether the size of operations warrants complexity of procedure. Very large

copper-mills employing gravity-concentration produce a concentrate which has been carried to the economical limit of purification by the method employed, but which is yet capable of mechanical improvement if a different property of the ore than its specific gravity be worked on. Electrostatic separation offers a means of reducing the silica and other objectionable constituents of the gravity-mill concentrates.

Zinc-blende usually occurs in mechanical association with pyrite or marcasite, chalcopyrite, galena, and one or more gangue-materials. The specific gravities of these minerals are approximately as follows: galena, 7.5; pyrite, 5.0; marcasite, 4.8; chalcopyrite, 4.2; blende, 4.; ordinary gangues, 2.7. From the smelters' stand-point, it is essential (for maximum recovery of the metal at minimum cost) that the material going into the lead-smelter be as free from zinc as possible; that into the copper-smelter, free from zinc and lead; and that into the zinc-smelter, as high in percentage of zinc as possible. Of the latter, theoretically, 67 per cent. is the maximum, but only in exceptional cases (as in the Joplin and Wisconsin districts) is 60-per cent. zinc-blende product obtained commercially by any method, while 50-per cent. zinc is for most complex ores considered excellent and 45-per cent. good. With ores in which the various mineral ingredients dissociate at a reasonable (30-mesh or coarser) degree of crushing, gravity-separators (jigs or water-tables) will usually effect a reasonably efficient separation of minerals which differ in specific gravity by 1.5 points, but as the difference in specific gravity becomes smaller the effectiveness of separation in this manner becomes less, so that with a difference of but one point, the effectiveness of the separation is poor. By putting such a complex ore, suitably crushed, through jigs and over reciprocating tables, the galena (with a portion of the pyrite or marcasite) is efficiently concentrated from the rest of the minerals. Likewise, the elimination of the gangue-rocks is also reasonably well effected. There are left together a greater portion of the pyrite or marcasite, the blende, and the chalcopyrite (with of course a little gangue and a small amount of galena). Fortunately, the galena (which is usually so small in amount as to be negligible except for the associated silver which often occurs in it), the pyrite or marcasite, and the chalcopyrite are excellent conductors of

electricity, while the blende and the small amount of gangue-rock are very much poorer conductors. In the utilization of this difference of conductivity is seen the application of the electrostatic process to this problem. This mixture, after drying (but not roasting), is passed through the Huff machines, and two products made, one for the zinc-smelter and one for the copper-smelter.

Blende often occurs in association with certain heavy gangue-rocks whose specific gravity is so similar to that of the blende that separation by any gravity means is very ineffective. A method has been developed by the Huff company whereby the surface of the blende can be made conducting, after which the blende can then be separated electrostatically from the associated rock-minerals. Two important instances of the above are blende and barite, and blende and fluorspar.

In addition to the concentration or separation of the sulphides mentioned heretofore, the Huff process has proved that it also accomplishes the following results very satisfactorily: concentration of gold and silver pyritic ores, of antimony, arsenic, and molybdenum sulphides; concentration of graphite, of pyrite for sulphuric acid manufacture, hematite, manganese-ores; the separation of galena and barite; purification of abrasives, natural and artificial; and the solution of many problems relating to the more rare minerals. Copper oxides, carbonates, and silicates can sometimes be concentrated, by first roasting to the conductive oxide, or reducing to the metal.

The process is essentially a dry one, obviating the troubles due to drought or freezing. The finished products require no further drying-treatment prior to shipment or smelting to decrease freight-expenses or fuel-costs. Loss in slimes is avoided, as the dust may be collected and is available for use if desired. There are no shaking or vibrating parts to the machines with the attendant wear and repair on the mechanism. The attendance necessary, after primary adjustment, is small and ordinary mill-labor is suitable. The machines are readily sectionalized for light transportation and easily assembled. There are no complicated or intricate parts to get out of order and the separators are readily adjustable while operating.

The Huff electrostatic process was started into field-operation in the spring of 1908, at the beginning of the present

general slump in the mining business. Nevertheless, the method has made progress, and wherever installed has been very successful. The first plant mentioned has been already described.[1]

At Midvale, Utah, the United States Smelting Co. has a very complex lead-zinc-copper-gold-silver ore, for which has been installed an electrostatic plant producing 50 tons daily of zinc- and iron-concentrates, the procedure in use being that above described for complex ores containing zinc. This plant also is described in the references quoted.

A further instance of the eminent adaptability of the Huff process to zinc-ore problems is the newly-constructed electrostatic mill at the Sunnyside mine, Silverton, San Juan county, Colo. This is treating about 40 tons per day, improving the zinc-concentrates obtained in the gravity-milling of the ores of the district.

There is also a 40-ton plant recently installed in Sonora, Mexico, which is giving excellent satisfaction in the separation of blende-chalcopyrite concentrates, producing a blende-product containing 55 per cent. of zinc and a copper-product assaying about 16 per cent. of copper.[2]

A plant recently installed by the Carborundum Co. at Niagara Falls, N. Y., is separating an impurity from artificial abrasive.

The cost of construction and of operation depends upon the general costs in the given region, upon the size of operations, upon whether the plant is run as an independent concentrator or as an adjunct to other operations. Therefore total-cost figures are of but little value unless presented with a complete description of the conditions of operation. The following detailed items are presented, which, by addition to suit the circumstances, will give a proper total.

Only the concentration- or separation-department is here considered, as the grinding-department is the same, independent of the method of concentration. A flow-sheet for the treatment

---

[1] *Transactions of the American Electrochemical Society*, vol. xviii., p. 267 (1910); *Mining World*, vol. xxxiii., No. 23, p. 1041 (Dec. 3, 1910); *Engineering and Mining Journal*, vol. xc., No. 1, p. 15 (July 2, 1910); *Metallurgical and Chemical Engineering*, vol. viii., No. 11, p. 636 (Nov., 1910).

[2] *Engineering and Mining Journal*, vol. xcii., No. 23, p. 1080 (Dec. 2, 1911).

of an ordinary crude ore in the concentrating-department, shown in Fig. 7, is as follows: rotary drier (not roasting), screens, roughing-machines to make a finished tailings; finishing-machines making finished concentrates, and a small middlings for return to the general system. The dust is drawn from each piece of apparatus and collected (to be used if sufficiently rich, and discarded if of little value). As the separators are upright, they occupy a space 6 by 1.5 ft., and are about 7 ft. high. Leaving sufficient space for attendance, a machine

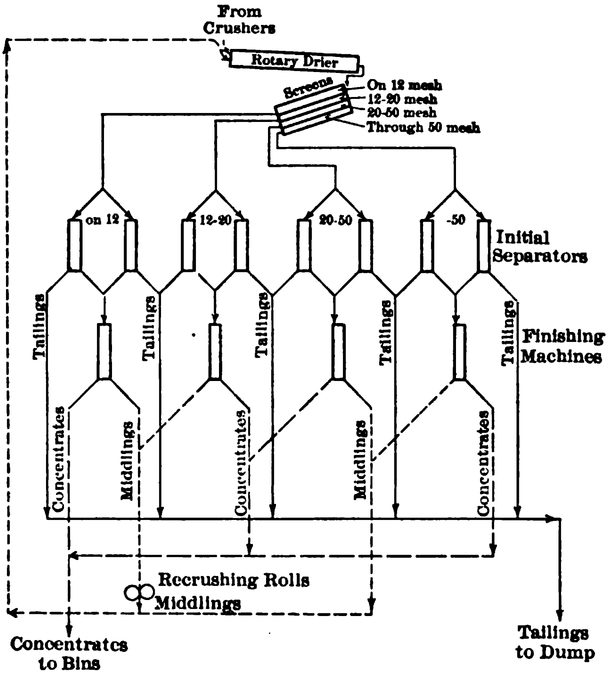


FIG. 7.—FLOOR-SHEET OF HUFF ELECTROSTATIC-SEPARATION PROCESS.

occupies a space 8 by 5 ft., or 40 sq. ft. of floor-space per separator. From 9 to 12 tons per separator can be taken as an average on the initial machine-floor, so that the tonnage-area of the building is about 4 sq. ft. per ton for the separators and about 6 sq. ft. per ton including elevators, belts, etc. The Midvale plant, with a daily capacity of 75 tons of very fine material, occupies a building but 40 by 40 ft. in area, but there is a very considerable amount of space unused at present. The drier is usually situated in the basement, and the screens in a

tower above the concentrator-floors. For a crude mill of 1,000 tons daily capacity, approximately 6,000 sq. ft. of building is necessary, or about 60 by 100 ft. The other costs of installation are similar to those of the ordinary gravity-concentration, except that the elevators do not have to handle water. Also, because of the small size of the building, there is a minimum of distributing-machinery.

The operating-costs outside of crushing-costs consist of: drying, power, labor, and repairs. The drying has been mentioned already, as has also the electrical power necessary for separation. The mechanical power for driving the separators is figured at $\frac{1}{8}$ h-p. per separator, including line-losses, so that in large installations the entire power, including elevators, screens, etc., amounts to approximately $\frac{1}{8}$ h-p. per ton of daily capacity. As everything in a properly-designed mill is automatically handled, with the exception of firing the drier, the labor required is needed only for properly keeping watch of the mill and for loading the products.

In general, the costs of operation in an electrostatic mill do not differ materially from those of a similar mill using reciprocating tables.

The Huff Electrostatic Separator Co. maintains at its Boston office a department for the investigation of various ore-dressing and allied problems.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The James Diagonal-Plane Slimer.

BY S. ARTHUR KROM, PLAINFIELD, N. J.

(New York Meeting, February, 1912.)

THE James diagonal-plane slimer is specially adapted to handle the finest slimes, but it will also handle sands as coarse as 40-mesh. The saving efficiency of this machine is due to the original construction of the deck, and to the rapid reciprocating movement imparted to it by the head-motion.

The deck consists of a plurality of connected planes, having a certain fixed ratio of inclination one to another. These planes intersect each other diagonally to the stroke-line of the table and are arranged so as to give the pulp on the table a double treatment. This double concentration performed by the diagonal-plane deck produces cleaner concentrates and tailings than those obtained by the operation of two separate machines. The action of the diagonal planes settles, combines, and holds all the concentrates in one compact mass, sharply defined from the gangue, and easily cut away without loss.

Many slime-concentrating machines distribute the feed-pulp for a distance of 4 or 5 ft. only, and upon a very limited settling-surface. This results in a thick, heavy deposit, from which it is impossible to stratify the values and wash away the gangue, the resulting products being dirty concentrates, and tailings carrying high values.

The diagonal-plane slimer distributes the feed-pulp for a distance of 10 ft., and upon a settling-surface having an area of 40 sq. ft.; in other words, it spreads the pulp thinly on the table, which allows the metallic values to settle through the gangue quickly, forming a bottom stratum from which the thinly-distributed overlying stratum of gangue is easily brushed away by the feed-water without disturbing the underlying concentrates.

Referring to Fig. 1, plane *A* is the main settling-section of the table. The feed pulp flows gently down this plane and is

not retarded until it reaches the lower edge of the plane, at which point the settled minerals are collected by the plane *B*, having less inclination than plane *A*, the feed-water and gangue flowing over them. A small portion of the gangue settles with the minerals. The main portion of the gangue is checked by planes *C*, called the "retarding-planes," and forms a buffer which assists the motion to form the minerals in a narrow, thick bed, and to drive them along the line of intersection of planes *A* and *B* towards their discharge-point. Upon reaching the retarding-planes *C*, the settled values are moved faster by the table-motion towards their discharge-point than the downward flow of the feed-water is moving them towards the tailings stratum, making the tendency to escape from their own formation very slight.

Planes *C* terminate 4 ft. short of the discharge-end of the table. At this point plane *B* gradually increases in width to the discharge-end of the table, forming a cleaning-area on which the minerals spread in a thin stratum, allowing the wash-water to carry away the remaining gangue. This gangue flows over the greater inclined plane *D*, together with the middlings and gangue discharged from the retarding-planes *C*, and the whole is arrested by the plane *E* and the retarding-planes *F*, and treated in the same manner as the pulp caught by the upper planes. The values settled and caught by the planes *E* and *F* are driven by the table-motion into, and consolidated with, the lower edge of the main concentrates stratum formed by the upper planes. With the proper amount of wash-water and feed, it is very difficult for the values to escape from all the planes.

The head-motion, illustrated by Fig. 2, is constructed to relieve the rapidly-rotating parts from the working-strains as much as possible. These strains are reduced by a system of levers from 6 to 1. In other words, if the table was bolted directly to the rotating-mechanism, these parts would have six times more pressure on them than under the lever construction.

Index-plates are provided as a guide to change the length and character of the stroke for various sizes of coarse and fine pulp.

A stroke-card of the table is shown in Fig. 3, in which curve 1 represents the stroke as set for treating fine minerals, the

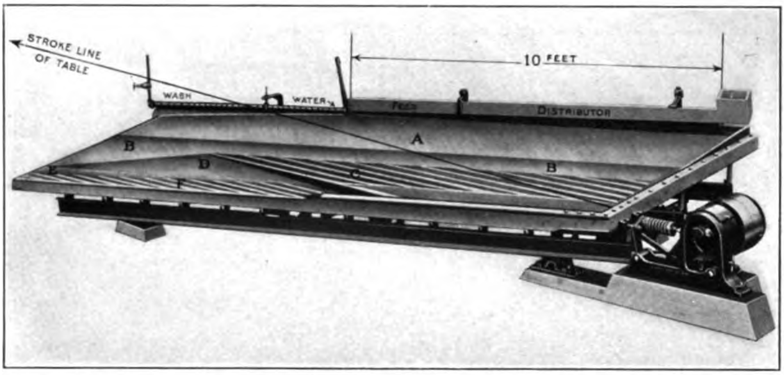


FIG. 1.—DECK-VIEW OF JAMES DIAGONAL SLIMER.

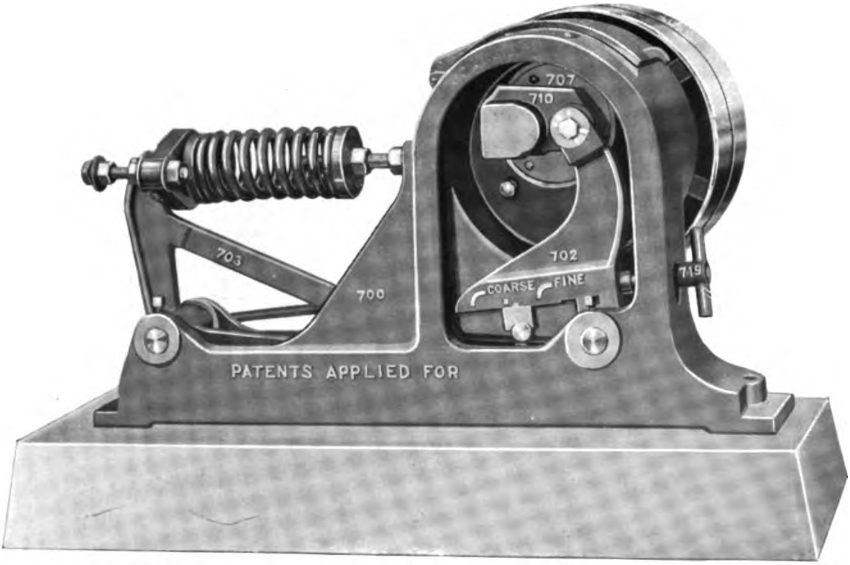


FIG. 2.—HEAD-MOTION OF JAMES DIAGONAL SLIMFR.

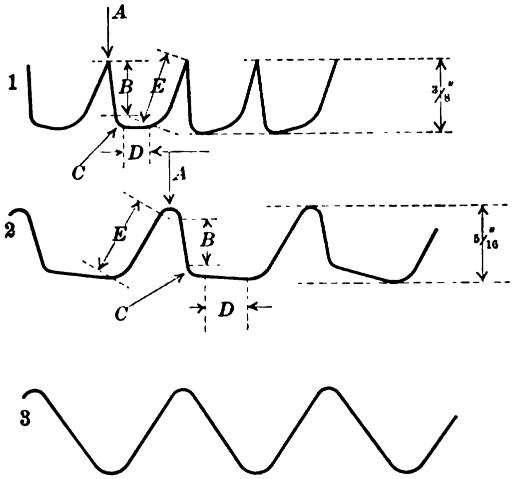


FIG. 3.—TABLE STROKE CARDS.

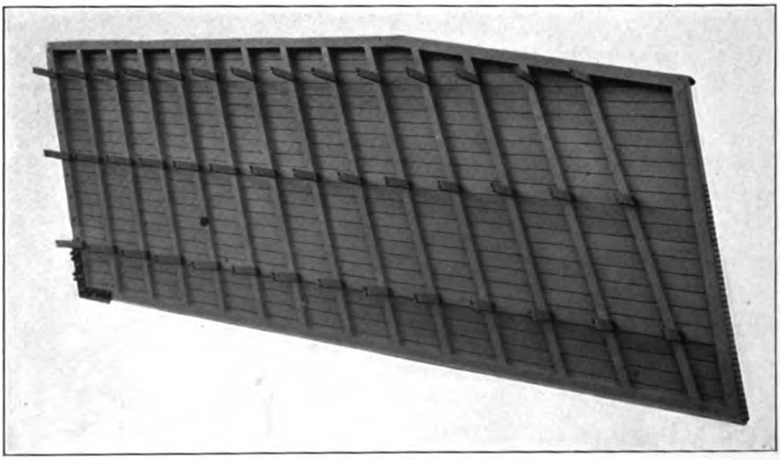


FIG. 4.—VIEW SHOWING METHOD OF SUPPORTING THE JAMES SLIMER DECK BY THE USE OF 42 CARRIERS.

length of stroke being about $\frac{3}{8}$ in. The sharp point of the outline at *A* shows the quick reversal of the table for the back stroke. The perpendicular part of the line at *B* indicates the rapidity of the back stroke to the curve *C*. During the passage of the stroke at *C* it slows down, coming to almost a dead stop while passing over *D*. This quiet action at *C* and *D* avoids throwing the fine pulp into such violent agitation that it would not have time to settle before the beginning of the forward stroke. The settlement being completed during the slow passage over *D*, the forward stroke begins, and gradually increases in speed as shown by curve *E*, until point *A* is reached again.

The stroke as set for coarse pulp is shown in Fig. 3, curve 2. It will be noticed that the reversal of the table for the back stroke at *A* is not so sharp as in the case of the slime-stroke; this slow reversal prevents packing and jamming the coarse pulp particles together, which would occur with a sharp reversal on this material. The quick portion of the reverse stroke at *B* is shorter, and the passage over *D* is faster, than in the treatment of slimes, owing to the fact that the settlement of the coarse pulp is not so easily disturbed and less time is required for settlement, hence the forward stroke can be started sooner than when treating slimes. Also, the speed of the forward stroke, it will be seen, is slower, in order to prevent driving the table from beneath the coarse pulp and failing to advance it.

When working fine material the stroke-reversal at *A* is 12 times faster than its speed at *D*, while in the case of the coarse pulp it is only four times that at *D*.

The revolutions per minute of the table being constant under all conditions, the length of the stroke must be kept within certain limits, otherwise the table-surface speed would increase to a point producing agitation sufficient to throw the pulp clear of the table, and prevent its settlement during the passage of the stroke over *D*. Thus the table would fail to advance the material properly through lack of contact.

Curve 3 illustrates the stroke produced by the regulation table toggle movement, the construction of which only allows a change in the length of the stroke. With this exception, coarse and fine pulps receive the same treatment.

Variations in the character of the stroke, as shown by curves 1 and 2, make it possible to produce cleaner products. The

capacity of the table is also increased, due to the fact that the separations are made quicker.

It has been found in practice that by changing the character of the stroke, separations can be made, assisted by the diagonal planes, of minerals heretofore very imperfectly concentrated in table-practice. Such separations as zinc from fluorspar, graphite from gangue, etc., are made very clean for commercial purposes by this combination.

The following is a comparison of results obtained by vanners and tables with riffled deck and toggle motion, and by the diagonal plane and differential motion, working the same feeds, in mill-practice.

	Tailings.
Riffles and toggles,	0.42 per cent. copper
Diagonal planes,	0.26 per cent. copper
Riffles and toggles, extraction (lead),	60 per cent.
Diagonal planes, extraction (lead),	80 per cent.

	Extraction.	Concentrates.	Tailings.
Frue vanner,	50 per cent.	50.0 per cent. lead	5 per cent. lead
Diagonal planes,	64 per cent.	48.8 per cent. lead	3 per cent. lead

Frue vanner, extraction (cobalt-silver),	40 to 50 per cent.
Diagonal planes, extraction (cobalt-silver),	76 to 82 per cent.

	Lead-Concentrates. Contain	Zinc-Concentrates. Contain
Riffles and toggles,	10 to 15 per cent. zinc	9.0 per cent. lead
Diagonal planes,	9 per cent. zinc	0.92 per cent. lead

Fig. 4 shows the method of supporting the table-deck. Forty-two carriers are hinged to the table, a canvas belt forming the hinge. The same material attaches the carriers to the channel-irons of the foundation frame. This construction shows no signs of wear after five years, running 24 hr. per day.

The construction of the deck itself is unusually light, and has a double advantage over the regulation heavy deck-construction, namely, the power required to oscillate the table is greatly reduced, and the deck is easily drawn to its proper bearings when being installed, eliminating all warping that may have occurred during transportation.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Treatment of Mine-Water from the Ashio Copper-Mine.

BY JOSEPH W. RICHARDS,* SOUTH BETHLEHEM, PA.

(New York Meeting, February, 1912.)

THE Ashio copper-mine of the Furukawa Mining Co. is situated 18 miles from Nikko, and 109 miles north of Tokyo, near the center of Japan. The mine-waters are run over scrap-iron, whereby most of the copper is precipitated as cement copper, leaving iron sulphate with some copper sulphate in solution. After using in the wet concentrating ore-dressing plant, the waste water contains clay and ore-slimes. The only avenue of disposal of this water is the Watarese river; but as this flows through valleys in which the water is used for irrigating the rice-crops, it is necessary to purify and clarify the water before discharge.

The water amounts to from 600 to 700 cu. ft. (from 17 to 20 cu. m.) per minute, and averages about 0.00025 per cent. of copper, representing more than 18 tons of copper per month. The water carries H_2SO_4, $FeSO_4$, $Fe_2(SO_4)_3$, $CuSO_4$ and other metallic sulphates in solution, and clay, ore-fines, slimes and basic iron sulphates as suspended matters. To purify and clarify the water, precipitation by milk of lime has been used, in three different ways, as follows:

I. *First Method, Copper not Recovered.*

Milk of lime was run into the water, and the mixture run through six settling-ponds, and then through a sand filter into the river. Fig. 1 is a view of the settling- and filtering-ponds. In the first pond, sand and metallic hydrates free from copper collected; in the next five ponds, slime, calcium sulphate, and metallic hydrates carrying copper settled out. The effluent carried from 0.1 to 0.05 mg. of copper per liter

* Professor of Metallurgy, Lehigh University, South Bethlehem, Pa.

(from 0.0001 to 0.00005 per cent.), indicating the precipitation of from 96 to 98 per cent. of the copper present in the water treated. The sand and metallic hydrates from the first pond were worthless; and although the precipitate taken from the other ponds carried from 1 to 1.5 per cent. of copper, yet the presence of about 25 per cent. of alumina and 60 per cent. of silica in it (caught by the flocculent hydrate precipitate) rendered it altogether useless for smelting, and it was removed to the dump. The 18 or 19 tons of copper per month in these waters was thus lost.

II. *Improved Method, to Enrich Precipitate.*

The water was first allowed to run through four settling-ponds, to aerate it and give the soluble sulphates a chance to precipitate the hydrates and thus entrain the colloids in suspension. The first pond gathered sand and slime, while in the next three were deposited some slime and metallic hydrates carrying from 0.5 to 1.0 per cent. of copper, and more than 70 per cent. of silica—a worthless material. In the fifth pond milk of lime was added, producing in this and the sixth pond a deposit consisting chiefly of calcium sulphate and metallic hydrates, but still mixed with considerable slime. This precipitate averaged, copper 4, iron oxide 22, alumina more than 20, and silica more than 30 per cent. While this precipitate was richer than that previously obtained, yet it was still too high in alumina and silica to pay to smelt it, and further effort was directed towards obtaining a richer copper-precipitate.

III. *Best Method, Saving the Copper.*

The water is run alone through three settling-ponds, in the first of which sand and slime settle, while in the second and third some precipitate of metallic hydrates settles, carrying some copper and slime high in silica, as explained in method II. In the fourth pond milk of lime is run in in small quantity, from 10 to 20 per cent. of the whole amount required for complete neutralization and precipitation. This causes a precipitate to settle, which is mostly hydrated iron oxide and free from copper, since there is from five to six times as much iron in the solution as copper; the flocculent precipitate also carries down with it most of the colloidal slime in suspension, con-

sisting mostly of alumina and silica. The water flows off into the fifth pond, where the rest of the lime necessary for the treatment is added. This precipitates the metallic hydrates completely, the precipitate settling in this pond and the next. The overflow from the sixth pond is passed through a sand filter before discharge, as before. Table I. presents three analyses of the precipitate recovered from tanks Nos. 5 and 6, which is dried and sent to the smelter, being rich enough in copper and low enough in alumina and silica to pay for the

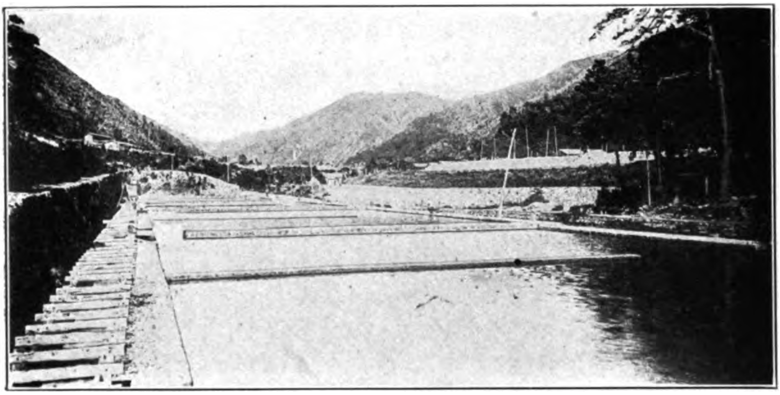


FIG. 1.—SETTLING- AND FILTERING-PONDS OF THE FURUKAWA MINING CO., ASHIO.

expense of treatment. The last column in this table gives the rational composition of the precipitate, calculated from the analysis of sample No. 3.

TABLE I.—*Analyses of Precipitate Dried at* 110° *C.*

	Sample No. 1. Per Cent.	Sample No. 2. Per Cent.	Sample No. 3. Per Cent.	Rational Composition of Sample No. 3.	Per Cent.
Cu	5.04	5.64	6.65	$CuO.H_2O$	10.18
Fe	11.93	12.67	14.14	$Fe_2O_3.3H_2O$	27.02
CaO	5.35	6.51	8.42	$CaSO_4.2H_2O$	25.86
Al_2O_3	4.92	4.90	3.28	$Al_2O_3.3H_2O$	4.93
Mn	3.85	4.66	3.70	$Mn_2O_3.3H_2O$	7.13
SiO_2	9.74	12.34	11.68	$SiO_2.2H_2O$	18.69
Loss on ignition,	30.28	31.08	31.34	Moisture,	4.88
					98.69

The method as thus improved not only saves 18 tons of copper per month, which was formerly lost as a worthless precipitate on the dump, but also gives clear waste water not injurious to agriculture.

In conclusion, I wish to thank the Furukawa Mining Co. for permission to make public this method of fractional precipitation (which is not covered by any patents, and is therefore free to the public), and to express my indebtedness to I. M. C. Imai, engineer of the company, for furnishing the notes on which this paper is based.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Notes on the Laramie Tunnel.

Discussion of the paper of David W. Brunton, presented at the San Francisco meeting, October, 1911, and printed in *Bulletin* No. 64, Apr., 1912, pp. 357 to 376.

W. L. SAUNDERS, New York, N. Y. (communication to the Secretary *):—The Laramie tunnel, though a small one, compares very favorably in the speed of driving with the great Alpine tunnels which have the record so far. I think it safe to say that, taking all things into consideration, the record made at Laramie is the best American record, though it still falls short of the long-tunnel records abroad.

In discussing tunnel-records it must always be borne in mind that there are conditions peculiar to each individual tunnel job, so that no comparisons are complete, fair and conclusive.

At Laramie there is one point which stands out prominently, and which distinguishes this from any of the recently-built Alpine tunnels, and that is that here we have great progress in an American driven tunnel without the use of a carriage for mounting the drills. At the Arlberg and Loetschberg tunnels, the carriage was an essential condition for progress. All the heading-drills were mounted upon a bar which rested upon a small carriage. This carriage was withdrawn after the drilling and run into the heading after the blast without much disturbance of the drills, and with very little adjustment except that required in jacking the horizontal bar across the tunnel. The carriage was so small in its track-area that it required little mucking to run it in to the face; and as the rock-drills used were heavy machines 3⅝ in. in diameter, progress in setting up and drilling was very much accelerated by the use of the carriage.

At the Laramie tunnel hammer-drills were used instead of piston-drills, and here we have an important distinction which

* Received Mar. 23, 1912.

admits of the use of a drill of light weight, and if drills of light weight are to be used in tunnel-driving no carriage is necessary. At Laramie the same horizontal-bar system was used, but the Laramie bar was very much smaller in diameter and very much lighter than the Loetschberg bar because hammer-drills do not kick back like piston-drills. With this light bar and these light drills the men were able to climb over the muck, jack the bar across the tunnel and begin drilling at the top while the mucking was going on below. This would be impracticable if large piston-drills such as were used at the Loetschberg had been employed at Laramie. Hence we may reasonably reach the conclusion that if light-weight hammer-drills will clean up as much ground in a certain time as heavy-weight piston-drills, there is no longer any necessity for a tunnel-carriage, and the simplicity of the plant is made possible.

In both the Loetschberg and the Laramie tunnels the headings were about 10 ft. wide; at least, this was the width of the first Loetschberg heading. At Laramie the height was 8 ft. and at Loetschberg 6 ft. 6 in. This additional height at Laramie called for the drilling of more holes and the removal of about 25 per cent. additional material. While this is a handicap in some ways, yet it is partly compensated for by the greater space it gives in which to work.

It is striking to notice, on comparing these tunnels, that at Laramie the actual drilling-time was more than double that at Loetschberg. At Loetschberg the holes were drilled to a depth of only 4 ft., this being repeated for each 8-hr. shift, while at Laramie the holes were much deeper, and it is readily understood that deep holes cannot be drilled at the average speed of shallow holes.

In the Loetschberg tunnel there were drilled 13 by 2 = 26 holes by 4 ft., equals 104 ft., and the actual drilling-time was 2 hr., or 52 ft. of holes were drilled per hour. In the Laramie tunnel there were 23 by 7.5 ft. = 172 ft., but the drilling-time was 5 hr., so that the number of feet drilled per hour was 172 $\div$ 5 = 34.5 ft., as compared with 52 ft.

There is a simple and self-evident explanation of the great discrepancy in these drilling-times. At the Loetschberg tunnel there were four drills in constant use, so that the record of feet per drill per shift was 104 $\div$ 4 = 26 ft. in 2 hr., or 13 ft. per

hour. In the Laramie tunnel, although this item does not appear in the paper under discussion, only two drills were at work constantly, and a third drill less than half the time, 2.4 drills being above the average. Then $172 \div 5 = 34.5$ ft. per hour $\div 2.4 = 14.4$ ft. per hour per drill, which figures out a slightly higher drilling-speed at Laramie, even with the disadvantage of drilling the deeper holes.

If it were not that the other operations of the cycle were done with remarkable celerity the time-record would not have been nearly as good as it is for the Laramie tunnel and it is evident that if more time could have been saved, it would have been in the actual drilling, by using more drills.

Mr. Brunton states in his paper:

"European tunneling-methods were copied as closely as the American wage-scale and differences of conditions would permit."

In this, of course, he refers to methods only and not to plant, because there is a distinct difference in the two systems so far as plant is concerned, though there is little or no difference in the system of blasting employed.

An important feature about the plant at Laramie is the fact that the drills were used with air and water passing through the steel to the bottom of the hole. This is known as the Water-Leyner system of drilling, and it is likely that the progress made in this tunnel is to a large extent due to the introduction of water and air at the bottom of the hole. This not only discharges the cuttings as fast as they are made, but it produces a clear atmosphere in the heading, enabling the men to work better. Air and water when mixed at the bottom of a drill-hole should not be confused with air alone or water alone. To attempt to blow out the cuttings in a heading-hole by air alone is to create a dust atmosphere that in time will produce sure death to those living in it. Furthermore, it clouds the headings and interferes with good work. The introduction of water alone does not accelerate the drilling as much as does the air-discharge. It has the further objection of being more expensive, since it requires water under pressure to be led to the heading. It is also undesirable because it makes a wet and foggy atmosphere in the heading.

H. Foster Bain, San Francisco, Cal. (communication to the Secretary*):—Mr. Brunton's paper will be welcomed by all engineers interested in tunnel-work. The results achieved in driving the Laramie tunnel mark a distinct advance in methods, and it is interesting to note that the progress is in the direction of European practice, namely, shorter holes and more rounds. The problem in rapid tunnel-driving is well recognized to be that of handling broken material in constricted space, and in Europe the effort has been to solve this by breaking less rock at one time, but firing oftener. A few years ago, in the United States, the large percentage of time used in setting up the drills led to strong efforts to drill and shoot long holes. The new drills, however, have greater speed, and being lighter and simpler, are more quickly set at work. As a result it is easier to "get in a round" than to "get out the muck." By drilling shorter holes, loading them heavily, and using a horizontal bar, the time lost in shooting is greatly reduced. It is interesting to compare the work done in the Laramie tunnel with that at the Elizabeth tunnel of the Los Angeles Aqueduct. In April, 1910, the south portal was advanced 604 ft., W. C. Aston being in charge. During May the north portal was driven 567 ft. under direction of John Gray. These were the records for American work in hard rock, prior to January, 1911, in which month greater speed was made in the Laramie tunnel. Details regarding the work are quoted below, being taken from the *Sixth Annual Report of the Bureau of the Los Angeles Aqueduct*, of which William Mulholland is Chief Engineer, and J. B. Lippincott, Assistant Chief Engineer.

The Los Angeles Aqueduct crosses under the crest of the coast range 45 miles north of the city of Los Angeles. The Elizabeth lake is approximately 0.5 mile east of the center of the tunnel, and a number of small lakes are situated in the valley westerly from Elizabeth lake. The tunnel is 26,870 ft. or 5.09 miles long. The coast range has a double crest at this point, with the valley of the Elizabeth lake almost in the center of the tunnel-line. Where the tunnel crosses this valley, it is 250 ft. beneath the surface of the ground.

Work was started by hand at the south portal on Oct. 5,

---

* Received Mar. 23, 1912.

1907, and at the north portal on Nov. 1, 1907, and was so prosecuted until adequate machinery could be installed. It was supposed that this long tunnel would be the controlling factor in the time necessary for the completion of the aqueduct. Consequently, equipment of a substantial character was placed here, consisting of four 500-cu. ft. per minute, two-stage air-compressors, which permitted duplicate air-installation at both the north and south ends. One 18-in. positive blower, and a track of 36-lb. rails on which electric locomotives were operated, were furnished for each portal.

The tunnel was driven on a slope of 1 ft. in 1,000. The timbered section required a theoretical excavation of 5.02 cu. yd. per linear foot, and the untimbered section 4.18 cu. yd. This is to be a pressure-tunnel, and is the outlet from the bottom of the Fairmont reservoir. It will be a portion of the penstock of the first power-plant south from the crest of the range. The amount of water discharged through the tunnel will vary with the load on the power-plants up to 1,000 cu. ft. per second, and average 400 cu. ft. per second for the day. The fact that the tunnel diverts from the Fairmont reservoir will permit of this fluctuation. As the electric load-factor in Los Angeles is estimated at 40 per cent., the maximum flow of water from the tunnel is 2.5 times the mean. The hydraulic gradient, therefore, will vary with the volume discharged, and will be cared for by the depth of 80 ft. of water over the intake of the tunnel.

The formation at the north half of the tunnel was very much broken and consisted mostly of decomposed granite. Much of the ground was very heavy, requiring close timbering, and in numerous places the tunnel had to be retimbered two or three times. Large flows of water were encountered, and also swelling ground. The excavation of this portion of the tunnel was most difficult, aud called for courage, skill, and persistence. At 1,117 ft. from the north portal, a large fissure filled with sand and water was encountered which broke through the face of the tunnel, and could not be passed from that side. This caused considerable delay. Therefore, a shaft was put down 3,000 ft. from the portal, and the heading driven each way therefrom, in order to maintain the progress-schedule and to approach the dangerous ground more guardedly from

the south. This running water and sand were finally overcome by driving overlapping steel rails in advance of the heading, and closely following with careful excavation and timbering. John Gray, superintendent for the north end, has accomplished a remarkable work in the driving of this half of the tunnel without further mishap.

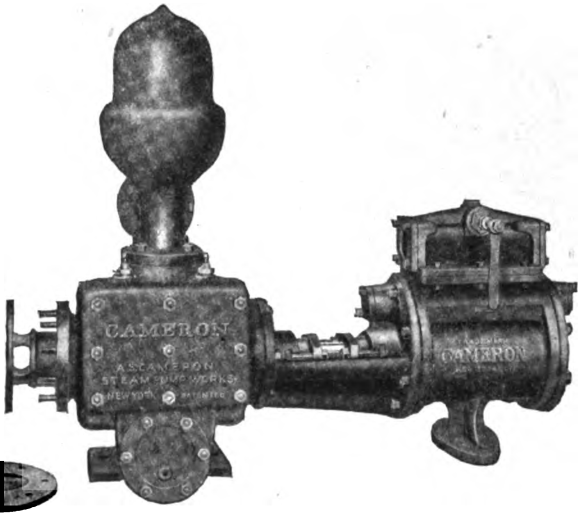
The south half of the tunnel was in a gneissoid granite, in some places rather soft, and in others hard. Broadly speaking, it was ideal tunnel-ground. This portion of the tunnel, as a rule, required no timbering. The south end was in charge of W. C. Aston, tunnel superintendent.

In driving the tunnel in hard rock, the full section was drilled and shot, each shift getting in a round and firing it. Where the ground was heavy at the north end, a lower heading was driven in advance, using false sets and crown-bars which carried the weight of the roof ahead of the front set. The tunnel was then widened by putting in the permanent posts, the temporary floor from which the upper section of the tunnel was excavated and mucked resting on them, the roof-segments being placed as the excavated material was removed, the whole process being one of a carefully detailed advance.

When this tunnel-work was started, it was estimated that a reasonable progress for each end would be 8 ft. per day with three 8-hr. shifts, and a bonus-schedule was adopted by the Board of Public Works, which provided that each man working in the tunnel, up to a shift of limited size, would receive a bonus of 40 cents for each foot that this schedule was exceeded, the progress to be measured at the end of each 10-day period. This bonus was paid in addition to the regular wages for tunnel-work in this section, the men receiving these wages whether the bonus-schedule was exceeded or not, and the bonus being distinctly a reward for extra exertion. As the costs for driving the tunnel are quite constant for each day's work, the cost per foot consequently would vary with the rate of progress, and it was estimated that this bonus would be considered as the men's equal share in the saving to the city resulting from the beating of the base-rate.

From the south portal, 13,500 ft. of tunnel was driven, and from the north portal, 13,370 ft. The average rate of progress at the south portal was 11.11 ft. per day; at the north portal,

after the connection was made through to the shaft, the average progress was 13.65 ft. per day. From the portal to the end of the section driven from the north end, including delays on account of shaft and cave-ins, the average progress was 11 ft. per day. The average progress for the two headings for the 1,215 days' work was 22.1 ft., or a little better than 11 ft. per day for each end. The connection of the two headings was made on Feb. 28, 1911, after the expiration of 40 months of work. (The time which the Board of Engineers estimated as necessary to complete this work was 5 years.) The center-line of the tunnel met within $1\frac{1}{8}$ in. and the grade checked within $\frac{5}{8}$ in. The total cost per foot for the driving of the tunnel, including administration, equipment, surveys, etc., but not lining, was $44.80, and the saving over the estimate of the Board of Engineers was about $500,000. An interesting feature of this work was that the tunnel was driven as rapidly and as cheaply near the center as it was near the portals; in other words, the transportation by electric locomotives and the strong ventilating-system were adequate to prevent delay. The organization of the work and the experience gained by the engineers rather reduced the unit-cost as the work proceeded. While almost the same distance was driven from both portals, the work at the north end was interrupted by excessive flows of water, which had to be pumped out. It is noteworthy that at the south portal of the tunnel, one 18-in. blower was sufficient to ventilate it quickly up to the last 1,000 ft. Great credit is due to the superintendents at both ends of the tunnel for the records made, in both speed and economy.


CAMERON
CAMERON

Water supply line of the Homestake Mining Company, Lead, South Dakota. Over 200 lbs. working pressure.

TAYLOR'S SPIRAL RIVETED PIPE

IS

THE MOST ECONOMICAL PIPE

and is extensively used by Yukon Gold Co., Chino Copper Co., Newhouse Mines & Smelters, Oliver Iron Mining Co., Prairie Pebble Prospect Co., Homestake Mining Co., Anaconda Copper Co., and many others. 3″ to 24″ diameter, asphalted or galvanized. Forged Steel Connections. Every length tested before shipment to 50% above required working pressure. Easily and quickly installed. Secure our Catalogue 5–M and allow us to quote you special prices on your requirements.

AMERICAN SPIRAL PIPE WORKS

N. Y. Office, 50 Church St. **P. O. BOX 485, CHICAGO**

The Roessler & Hasslacher Chemical Company

Works

PERTH AMBOY, NEW JERSEY

100 William Street

NEW YORK

THE ROESSLER & HASSLACHER CHEMICAL COMPANY. CHEMISTS NEW YORK TRADE MARK

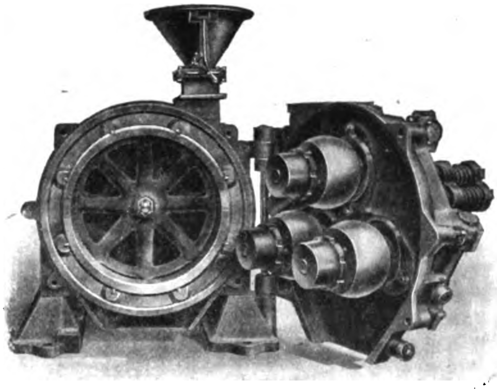
CYANIDE 98-99%

(Old standard) 39% Cyanogen.

CYANIDE OF SODIUM 128-130%

(New standard) 52% Cyanogen.

STURTEVANT



RING-ROLL ORE PULVERIZER

FOR DRY GRINDING

OUTPUT :	6 TO 10 TONS PER HOUR TO 40 MESH	35 TO 45 HORSE POWER
	5 " 6 " " " 60 "	
	2 " 4 " " " 100 "	

Send for Catalogue

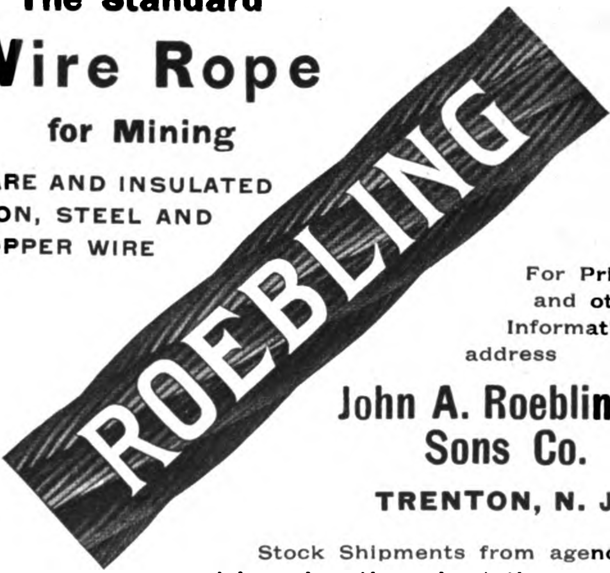
STURTEVANT MILL CO., **BOSTON, MASS.**

The Standard

Wire Rope

for Mining

BARE AND INSULATED IRON, STEEL AND COPPER WIRE



For Prices and other Information, address

John A. Roebling's Sons Co.

TRENTON, N. J.

Stock Shipments from agencies and branches throughout the country

BEER, SONDHEIMER & CO.

Frankfort-on-Main, Germany

NEW YORK OFFICE - - 42 BROADWAY

Zinc Ores, Carbonates, Sulphides and Mixed Ores, Copper Ores, Copper Matte, Copper Bullion, Lead Bullion, Lead Ores, Antimony Ores, Iron and Manganese Ores, Copper, Spelter, Antimony, Antimonial Lead, Sulphate of Copper, Arsenic, Zinc Dust.

Own Smelting and Refining Works

L. VOGELSTEIN & CO.

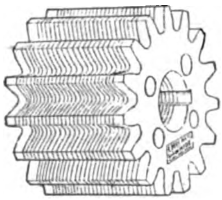
42 Broadway **NEW YORK**

BUYERS, SMELTERS AND REFINERS OF

Ores and Metals of All Classes

Agents for:

Aron Hirsch & Sohn, Halberstadt, Germany.
United States Metals Refining Co., Chrome, N. J. and Grasselli, Ind.
American Zinc, Lead & Smelting Co., Caney and Dearing, Kansas.
Kansas Zinc Co., La Harpe, Kansas.
The Electrolytic Refining & Smelting Co. of Australia, Ltd., Port Kembla, N. S. W.



Chicago-Rawhide Pinions

The best that selected material and careful workmanship can produce

The Chicago Rawhide Mfg. Co.

1301 Elston Avenue **CHICAGO, ILL.**

A Durable Metal Coating for all Metallic Surfaces

SEMPLE'S BLACK OXIDE PAINT
LASTS FROM 6 TO 10 YEARS

Air, acid and water proof. Sulphur water does not feaze it. Kills rust already formed and prevents rust formation. Dries readily when applied to dry or wet surfaces and will not run when surface is frosty. Bakes fast to hot stacks.

PRICE $1.00 PER GALLON.

Manufactured by

Established 1870. **F. G. SEMPLE, South Bethlehem, Pa.**

METALLURGICAL EQUIPMENT

A DIRECTORY OF MINING AND

ELECTRIC COAL CUTTERS MINE LOCOMOTIVES	**GOODMAN MANUFACTURING CO.** Chicago, Illinois. ELECTRIC AND AIR POWER COAL CUTTERS. ELECTRIC MINE LOCOMOTIVES. POWER PLANTS.

CONVEYOR BELTS	**THE B. F. GOODRICH CO.** Akron, Ohio. Goodrich "Longlife" "Economy" & "Grainbelt" CONVEYOR BELTS will handle more tons per dollar of cost than any other belts made.

PERFORATED METALS	**HARRINGTON & KING PERFORATING CO.** 621 North Union St., Chicago, Ill., U. S. A. New York Office: 114 Liberty St. Manufacturers of Perforated Metal Mining Screens of every description, and for screens of all kinds. See advertisement on page 4.

SPELTER SHEET ZINC SULPHURIC ACID	**ILLINOIS ZINC CO.** Peru, Ill. Manufacturers of SPELTER, SHEET ZINC and SULPHURIC ACID.

COAL MINING MACHINERY	**INGERSOLL-RAND CO.** 11 Broadway, New York. "Return-Air" Pumps, Coal Shearers, Pneumatic Hoists, "Electric-Air" Drills, Coal Punchers, Pneumatic Tools, "Calyx" Core Drills, Plug Drills, Hammer Drills, Tamping Machines, Rock Drills, Air Lift Pumps.

ROCK DRILL STEEL HOLLOW SOLID	**INTERNATIONAL HIGH SPEED STEEL CO.** New York City. Sole Importers of the Celebrated "BULLDOG" BRAND HOLLOW AND SOLID ROCK DRILL STEEL.

METALLURGICAL EQUIPMENT

THE JEFFREY MFG. CO. Columbus, Ohio. Electric and Air Power Coal Cutters and Drills, Car Hauls, Coal Tipples, Coal Washeries, Larries, Screens, Cages, Crushers, Elevators, Conveyors, Fans, Hoists, Pumps, etc.	COAL MINING MACHINERY
LEAD LINED IRON PIPE CO. Wakefield, Mass. LEAD LINED IRON PIPE, LEAD LINED IRON VALVES—for Acids and Corrosive Waters.	LEAD LINED IRON PIPE AND VALVES
A. LESCHEN & SONS ROPE CO. IN BUSINESS [illegible] YEARS New York Chicago **St. Louis, Mo.** Denver Seattle Producing WIRE ROPE of qualities and construction adapted to every condition of wire rope service, including the celebrated Hercules Brand and Patent Flattened Strand and Locked Coil constructions. Systems of Aerial Wire Rope Tramways for the economical transportation of any material.	WIRE ROPE AERIAL WIRE ROPE TRAMWAYS
THE LODWIC CONCENTRATOR CO. Los Angeles, Cal. Manufacturers of LODWIC CONCENTRATORS. Write us for information, prices and terms.	LODWIC CONCENTRATOR
MACOMBER & WHYTE ROPE CO. Chicago, Ill. New York Pittsburg Kansas City Seattle Portland Manufacturers of High Grade Wire and Wire Rope for every purpose. Sole makers of Patent Kilindo Non-rotating, "Monarch" and MacWhyte Wire Ropes. Lawson Looped Section Tramways.	WIRE ROPES AERIAL WIRE ROPE TRAMWAYS BLOCKS FOR WIRE ROPE
MASHEK ENGINEERING CO. 90 West St., New York. Complete plant equipments 4, 8, 16 and 35 tons of 2 to 3 oz. smokeless and odorless briquettes per hour. Complete plants designed and erected.	BRIQUETTING MACHINERY

A DIRECTORY OF MINING AND

ELECTRICAL COAL MINING MACHINERY	**MORGAN-GARDNER ELECTRIC CO.** Chicago, Ill. ELECTRICAL COAL MINING MACHINERY, ELECTRIC MINE LOCOMOTIVES, DYNAMOS, SWITCH BOARDS and MINE SUPPLIES.
ELEVATORS OF ALL KINDS FOR MINING USE	**OTIS ELEVATOR COMPANY** Eleventh Ave. and Twenty-Sixth St., New York. OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD. Build and erect all types of Freight and Passenger Elevators—for all kinds of power;—including Furnace Hoists, Inclined Railways, and Special Hoisting Equipments and Machines for Mining use. Correspondence invited.
CONVEYOR BELTING	**QUAKER CITY RUBBER COMPANY** Philadelphia, Pa. We are the sole manufacturers of Ridgway patented Hinge Edge Belt for trough conveying. We also manufacture regular styles of Conveyor Belt. Belting for Bucket Elevators a specialty. Tell us your belting problems.
ROBINS BELT CONVEYORS	**ROBINS CONVEYING BELT COMPANY** 13-21 Park Row, New York. Messiter ORE BEDDING Systems—FURNACE FEEDERS; SORTING BELTS, and many other special applications of what was the Pioneer and is the Standard Belt Conveyor; Coal Handling Systems; Electric Locomotives; Hoisting Machinery.
WIRE ROPE	**JOHN A. ROEBLING'S SONS CO.** Trenton, N. J. WIRE ROPE for mining work. Stock shipments from agencies and branches throughout the country.
POSITIVE PRESSURE BLOWERS VACUUM AND ROTARY PUMPS GAS EXHAUSTERS	**P. H. & F. M. ROOTS CO.** Connersville, Ind. Manufacturers of the Roots Positive Pressure Blowers for Smelting, Foundry and Filtration Work. Write for Catalogue.

METALLURGICAL EQUIPMENT

STURTEVANT MILL CO. Boston, Mass. STURTEVANT Steel Plate Crushers, Balanced Rolls, Ring-Roll Pulverizers, Newaygo Screens, Laboratory Crushers, Rolls and Screens.	CRUSHING GRINDING SCREENING MACHINERY
SULLIVAN MACHINERY CO. Railway Exchange, Chicago, Ill. Coal Pick Machines, Air Compressors, Diamond Core Drills, Rock Drills, Hammer Drills, Mine Hoists, Chain Cutter, Bar Machines, Fans.	ROCK DRILLS AIR COMPRESSORS HOISTS PUMPS
VULCAN IRON WORKS Wilkes-Barre, Pa. Vulcan Electric Mine Hoists, Steam Hoists, Hoisting and Haulage Engines, Mining Machinery, etc. Nicholson Device for Prevention of Overwinding.	MINE HOISTS
WESTINGHOUSE ELECTRIC & MFG. CO. Pittsburg, Pa. The Westinghouse EQUALIZER HOISTING SYSTEM will solve your hoisting problems.	ELECTRIC HOISTS
WESTON ELECTRICAL INSTRUMENT CO. Waverly Park, Newark, N. J. Weston Eclipse AMMETERS, MILLIAMMETERS and VOLTMETERS are well suited for D. C. Circuits of small mine plants.	AMMETERS AND VOLTMETERS
DIRECTORY CARDS RATE FOR PUBLICATION OF CARDS IN THE DIRECTORY OF MINING AND METALLURGICAL EQUIPMENT WILL BE QUOTED ON REQUEST.	RATES